THE PRODUCTION ENGINEER

DETROIT PUBLIC LIBRARY

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

APRIL 1960

THE PRODUCTION ENGINEER

VOL. 39 - No. 4 PRICE 10/- APRIL 1960

CONTENTS

"ENGINEERING PRODUCTION RESEARCH" by Professor N. A. Dudley, Ph.D., B.Sc., M.I.Prod.E. 195

"INVENTORY CONTROL — A PROBLEM IN STOCKING PERISHABLE GOODS" by Dr. Samuel Eilon, M.I.Prod.E. 210

"SHEAR ON PRESS TOOLS — A NEW APPROACH" by J. A. Saunt, A.R.Ae.S., A.M.I.Prod.E., M.I.Plant.E. 216

"FRICTION AND LUBRICATION IN ENGINEERING PRODUCTION — WIRE, TUBE AND BAR DRAWING" by J. S. Hawkins, Grad.I.Prod.E. 226

CORRESPONDENCE 235

REPORT OF THE MEETING OF COUNCIL 28th January, 1960 236

COUNCIL ELECTIONS 239

ELECTIONS AND TRANSFERS 240

"MISSING" MEMBERS 242

DIARY FOR 1960 245

INSTITUTION NOTES 246

NEWS OF MEMBERS 248

HAZLETON MEMORIAL LIBRARY — ADDITIONS 249

The Institution of Production Engineers does not accept responsibility for any statements made or opinions expressed in any Papers published in the Journal of the Institution

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

10 Chesterfield Street
Mayfair : London : W.1
Telephone GROsvenor 5254-9

EDITORIAL COMMITTEE
B. E. Stokes — Chairman
G. Ronald Pryor—President of the Institution
H. W. Bowen, O.B.E. — Chairman of Council
John Mitford Brice
J. L. Gwyther
H. Peter Jost
J. C. Z. Martin
J. J. Peck
R. V. Rider
M. J. Sargeaunt
R. J. Temple

EDITOR
M. S. C. Bremner

SECRETARY OF THE INSTITUTION
W. F. S. Woodford

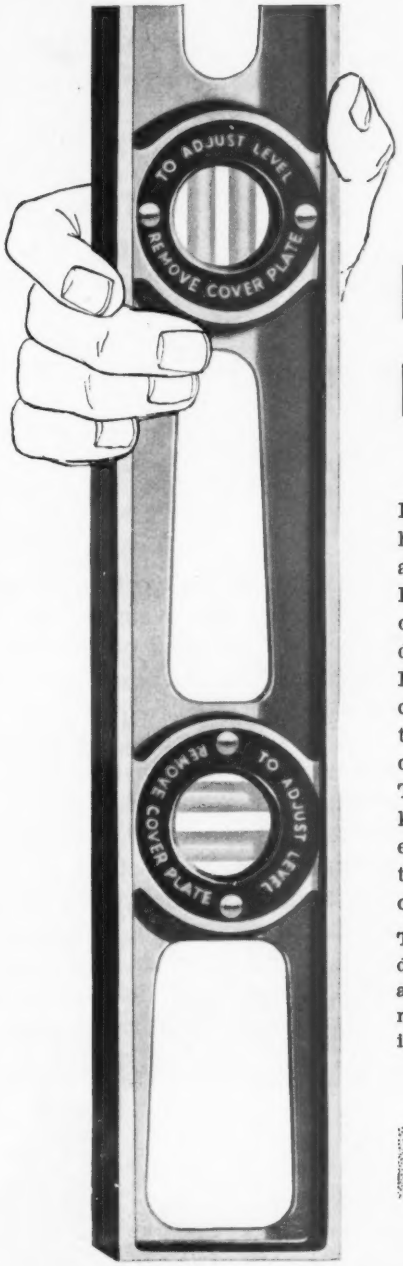
The Production Engineer, April 1960

INVENTORY CONTROL

A Problem in Stocking Perishable Goods

ERRATA

Page	*Column*	*Line*	*Printed*	*Correction*
Throughout		for	$\int_D^Q$	read $\int_0^Q$
211	left	4 from bottom	δ	σ
213	left	5 from top	charged	charges
213	left	equation (13)	$\frac{C}{\delta c_2}$	$\frac{C}{\sigma c_2}$
213	left	middle page	$\int_D^T$	$\int_0^T$
213	left	middle page	$\int_D^{t_0}$	$\int_0^{t_0}$
213	left	equation (16)	(blurred)	$(1+\varepsilon_1+\frac{1}{2}\varepsilon_0)$
213	right	6 from top	optimal solutions may ...	different optimal solutions ..
214	left	paragraph 3	$\zeta=0$	$\zeta\neq 0$
215	left	11 from top	$\frac{dL>0}{dD_1}$	$\frac{dL}{dD_1}>0$
215	left	16 from top		cross out "as in Fig. 5"
Appendix	left	4 from top	(blurred)	$\bar{\phi}(t)=\int_{-\infty}^{t}\varphi(t)\,dt$
Appendix	right	wherever you find tD_1		${}^tD_1$
Appendix	right	wherever you find tD_2		${}^tD_2$



In hand but out of mind

Picture a builder, his hand on the level, his eye on the bubble. How rarely does he take an interest in the spirit level's casing! How rarely does he need to when, like so many other familiar things around us, its stability depends on a Birmal casting.

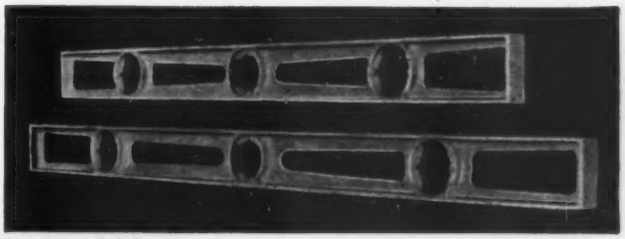
Dependable Birmal! For more than 50 years Birmal craftsmen have been producing castings to support, to enclose, to provide the very foundation of a host of well-known products.

Their technical skill and great experience keep Birmal ahead in foundry practice . . . ensure that Birmal castings will continue to be relied on wherever the quality of castings counts.

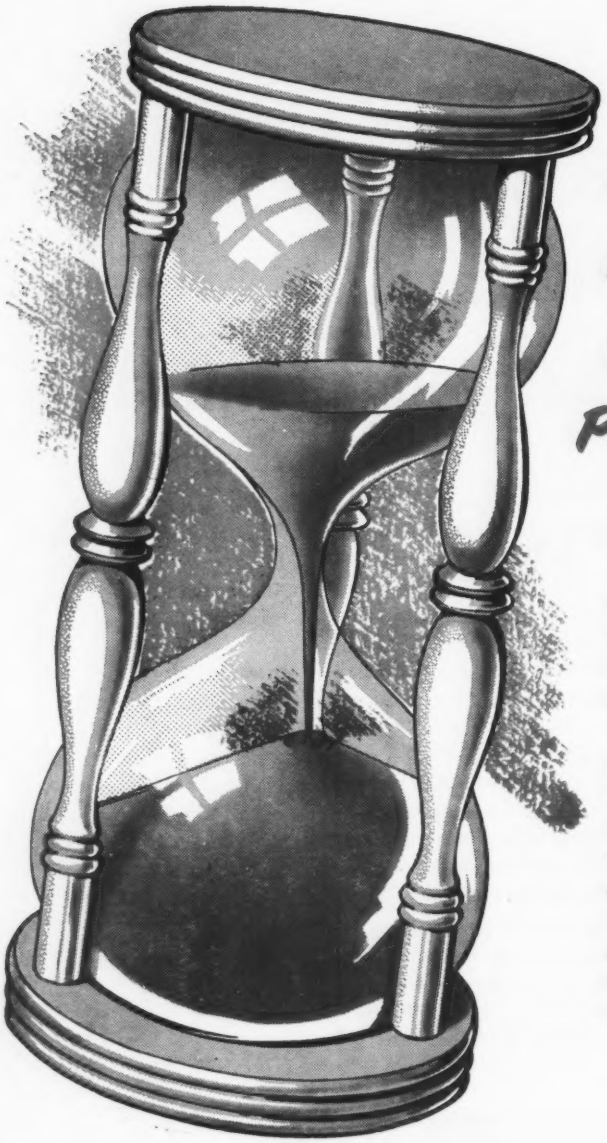
The Birmal foundries produce sand and gravity die castings in aluminium and magnesium alloys, and pressure die castings in aluminium, magnesium and zinc alloys for use in practically every industry.

BIRMAL

Pressure die cast in aluminium alloy for John Rabone & Sons Ltd.



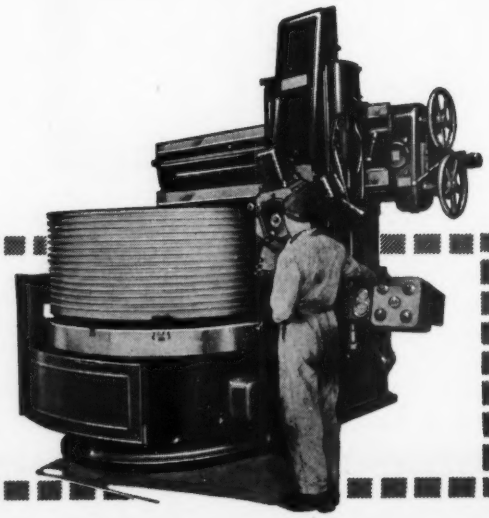
Birmingham Aluminium Casting (1903) Co. Ltd Birmid Works Smethwick 40 Staffs



A COMPANY IS KNOWN BY THE CUSTOMERS & PROMISES IT KEEPS

Although the world-wide reputation enjoyed by the Webster and Bennett Boring Mill is based on inherent quality and fitness for purpose there are other aspects of service of equal importance.

One of those which is of particular pleasure and satisfaction to our customers, and a source of pride to ourselves, is a punctilious observance of delivery dates. No effort is spared to meet a promised delivery and although unforeseen circumstances have frequently arisen, sufficient in themselves to justify a delivery extension, deliveries quoted for machines have never been broken.



The illustration shows a Webster and Bennett 60″ Boring and Turning Mill at the Bradford Works of Crofts (Engineers) Ltd., machining a 60″ diameter vee groove pulley with a face width of 26″ having 18 grooves 1¼″ wide by 1¼″ deep.

WEBSTER & BENNETT LTD., COVENTRY, ENGLAND

An ordinary bush may cost less to buy—

but a B·A·C bush costs less to use!

..NITRIDED FOR LONGER LIFE

WORLD'S BEST DRILL BUSH

COMES QUICKEST... LASTS LONGEST...

Quality ... the best economy of all ... B·A·C ... The bush with nine lives ...

591 Cogent

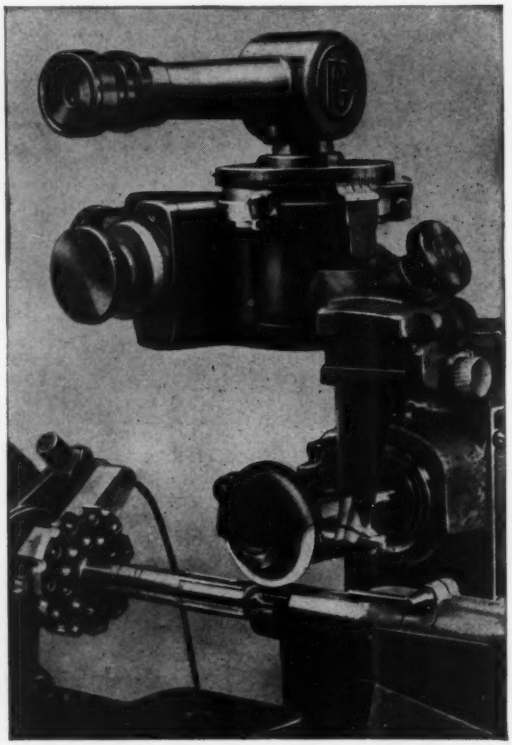
BRITISH AERO COMPONENTS LTD. WARWICK. TEL 320

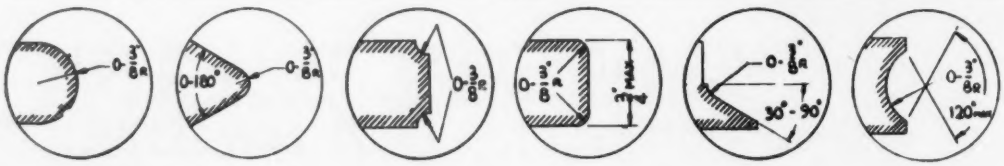
the PG OPTIDRESS

for wheelforming under optical control without template

The unit is permanently attached to the head of the machine. One radial and two tangential straight line motions can be carried out in one setting. Additional wheel dressings are undertaken by operating the micrometer controlled cross slides, thus permitting the dressing of intricate profile combinations along the periphery of the wheel. The microscope facilitates quick and accurate diamond settings and the checking of the grinding wheel after dressing. Commercial diamonds can be employed since the radial dressing motion is viewed against a graticule.

Patent Pending on No. 36115/58





FOR GOOD FORM CHOOSE THE...

P.G. OPTIDRESS

NRP 2726

PRECISION GRINDING LTD

MILL GREEN ROAD · MITCHAM · SURREY Phone: MITCHAM 3014

...With the compliments of

DORMER

THE SHEFFIELD TWIST DRILL AND STEEL COMPANY LIMITED
SHEFFIELD **ENGLAND**

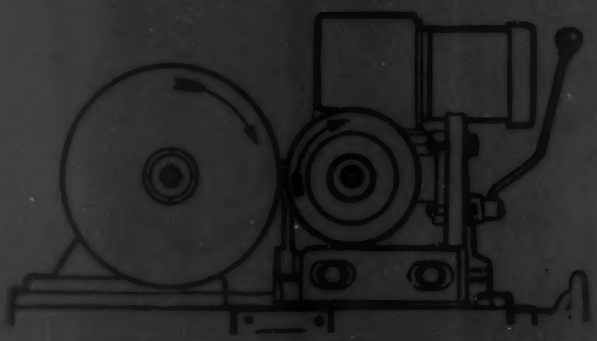
DORMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS

CANNING

CENTRELESS

POLISHING MACHINES

FOR THE RAPID FINISHING OF TUBES, RODS AND A WIDE VARIETY OF CYLINDRICAL SHAPES



Component is fed between the polishing mop and the feed roller.

Centreless machines save time and labour.

- They give a uniform finish at low cost.
- Can be operated by unskilled labour.
- Have a high output capacity.
- An adjustable rate of feed.
- Are available in three types to suit all requirements.

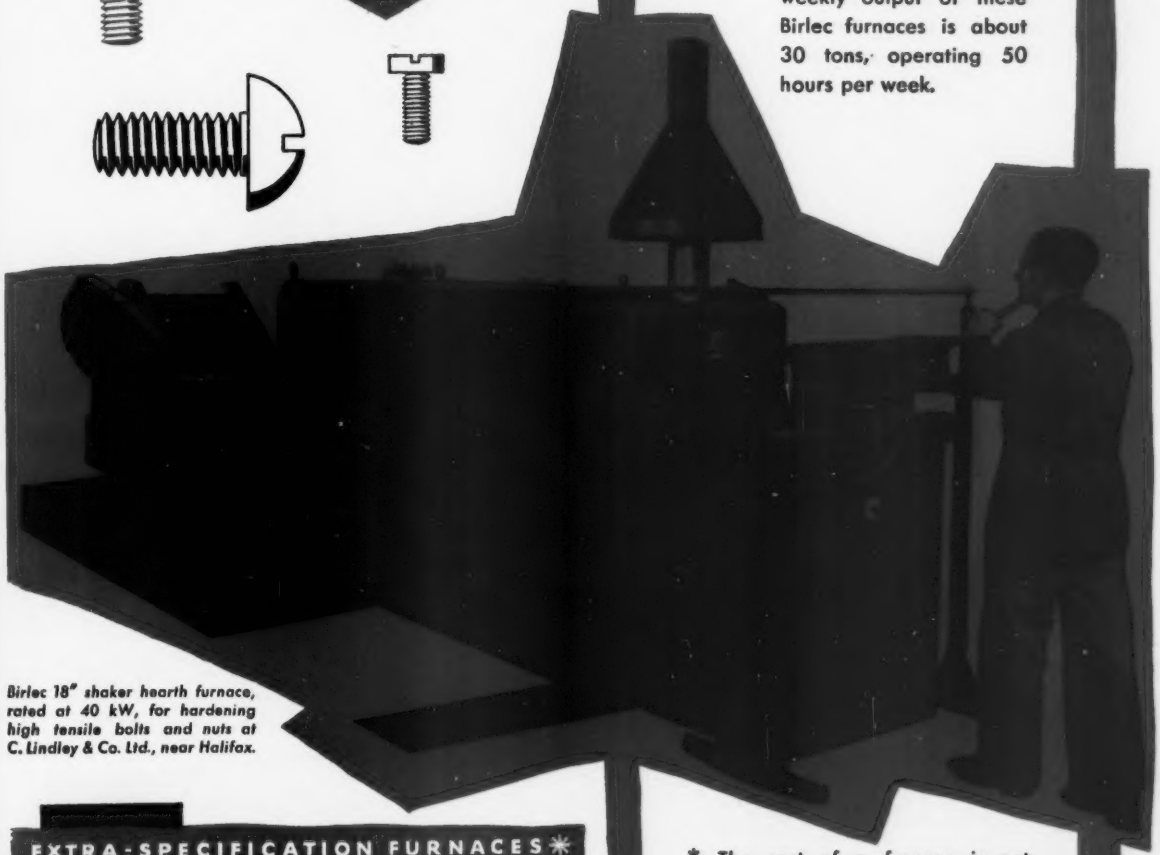
Attachments are supplied to enable a wide range of circular articles to be polished.

Please ask for publication No. 1038.

W. CANNING & CO. LTD. BIRMINGHAM 18. *Telephone: CEN. 8621* LONDON & SHEFFIELD

SECURED BY A THREAD

Whether it be a Whit., BSF, UNF, UNC, or B.A. thread it is all the same to C. Lindley & Co. Ltd., Luddenden, Yorkshire. They make all types of standard high tensile bolts and nuts from 4 B.A. to $\frac{5}{8}$" diameter and are well known for the manufacture of special parts by the cold heading method. Their heat treatment, which involves hardening, tempering and normalising, is entirely carried out in four Birlec atmosphere controlled furnaces including 18" and 24" Birlec shaker hearths, and Birlec cast link conveyors. The weekly output of these Birlec furnaces is about 30 tons, operating 50 hours per week.



Birlec 18" shaker hearth furnace, rated at 40 kW, for hardening high tensile bolts and nuts at C. Lindley & Co. Ltd., near Halifax.

EXTRA-SPECIFICATION FURNACES*

BIRLEC

AEI-Birlec Limited

ERDINGTON · BIRMINGHAM 24 · Tel. EASt 1544

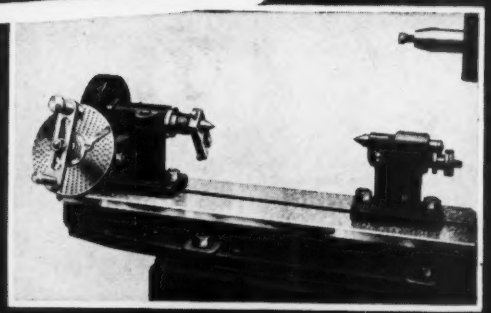
LONDON · SHEFFIELD · NEWCASTLE-ON-TYNE
GLASGOW · CARDIFF

SM/B 5037

** The cost of a furnace is not necessarily its purchase price. Even a brief interruption in production may cause severe losses in output and serious inconvenience. The purchaser of a Birlec furnace can be confident that the equipment will not only meet his specification, but will give uninterrupted trouble-free service.*

CROWTHORN

19½" STROKE SHAPING MACHINE



The Crowthorn 19½" stroke Shaping Machine is of heavy design for rigidity and accuracy. Special features include automatic force feed lubrication, self contained motor drive and the wide range of attachments available. Early delivery is now offered.

Indexing Attachment for gear-cutting etc. A Slotting Attachment can also be supplied

* *Send for new fully illustrated literature*

CROWTHORN ENGINEERING COMPANY LIMITED

Makers of High Class Machine Tools for over half a century

REDDISH · STOCKPORT · ENGLAND

Phone: STOCKPORT 7271-2-3 *Grams: CROWTOOL, REDDISH*

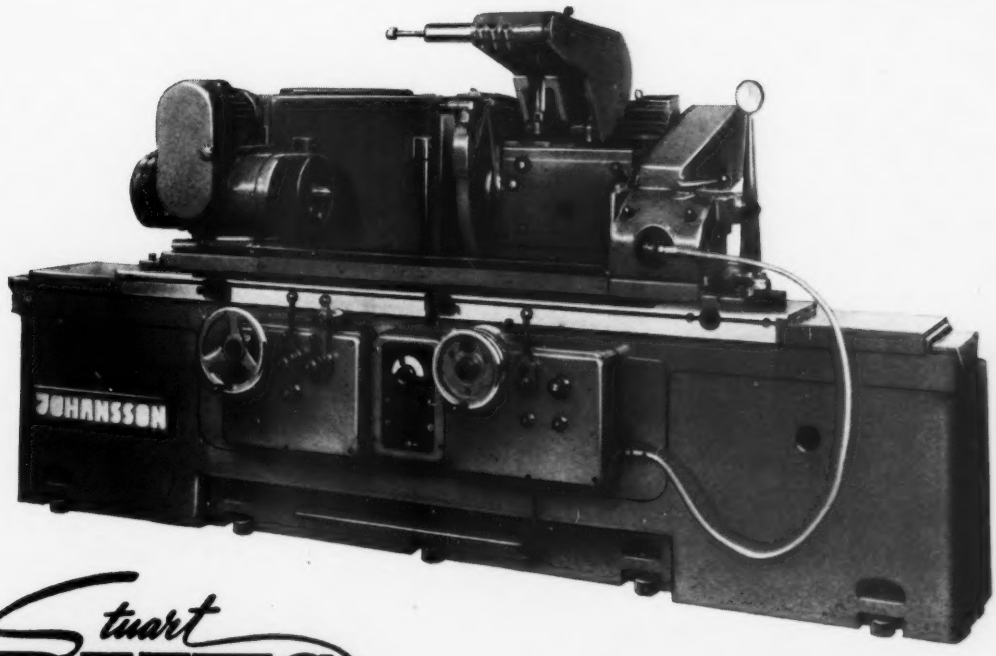
CL98

Sole concessionaires for

S. W. BUNDGENS
WIRE STRAIGHTENERS
SCHUMAG CENTRELESS GRINDERS
BURKHARDT & WEBER MULTI-SPINDLE DRILLING MACHINES
CHAPPUIS PROGRESSIVE TOOL PRESSES
MALMEDIE COLD HEADING MACHINES
REINECKER GRINDING MACHINES
MENGELE HYDRAULIC PRESS BRAKES
and many others.

JOHANSSON Production Universal Grinding Machines

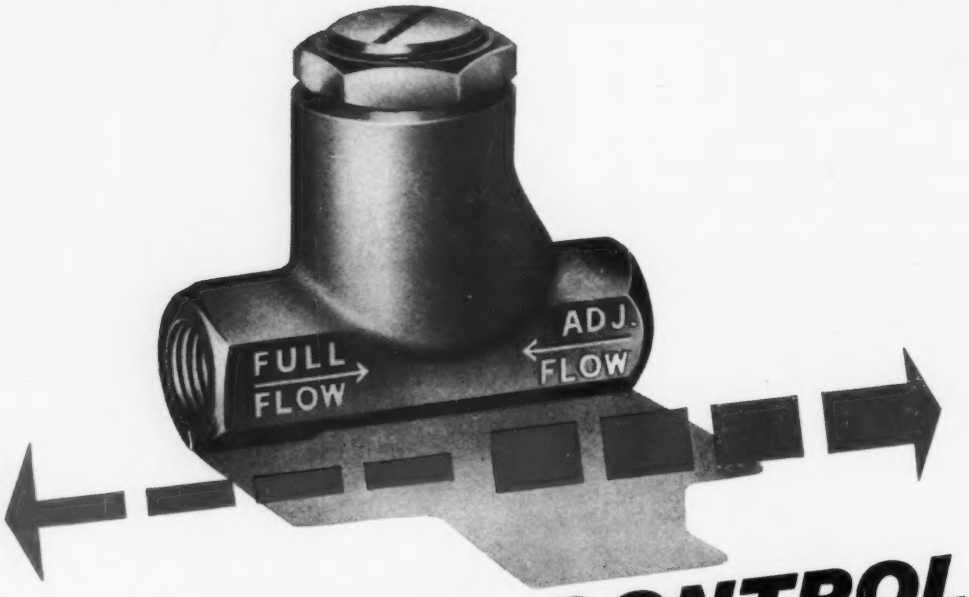
Cold running spindle in plain bearings. Hydraulic wheel feed in direction of head setting. Fully automatic hydraulic machine cycles including work sizing. Hydraulic profile dressing. Symetrical work head usable either end of table. Table reversal within 0.004"



Stuart DAVIS LTD

MUCH PARK ST., COVENTRY

Catalogues and literature on request to sole concessionaires



FLOW CONTROL

SCHRADER FLOW CONTROL VALVES provide a control of movement speed so essential to the effective use of compressed air equipment. The range of valves has now been extended to give even greater flexibility.

The valve is easily set, by means of an adjustment screw, thus determining how fast the air flows in the "adjusted" direction. If used in conjunction with an air cylinder, for instance, the valve can control the pressure build-up and with it the *speed* of the piston thrust, but not its pushing force. This controlled thrust speed avoids the impact shock of suddenly applied air pressure, yet permits full thrust force. When the valve is operating in the "full flow" direction a poppet is opened, giving open line pressure. Where controlled air flow is required in both directions, two valves can be fitted back-to-back.

Although designed primarily for air control, these valves are equally suitable for use with oil or water in hydraulic systems.

Body of cast brass.
Non-corrodible plunger assembly, replaceable in one unit.
Substantial lock-nut resists vibration.

The $\frac{1}{8}$" bore valve is the latest addition to the Schrader range, which now covers $\frac{1}{8}$", $\frac{1}{4}$" and $\frac{3}{8}$" B.S.P. sizes. These provide a pressure range as follows :—AIR : 0-400 P.S.I. OIL or WATER : 0-800 P.S.I.

Schrader
FLOW CONTROL VALVES

- LARGE POPPET TYPE PLUNGER PERMITS FAST, FULL RETURN FLOW.
- LARGE DIAMETER STAINLESS STEEL SEAT GIVES ACCURATE CONTROLLED FLOW. NO NEEDLE POINTS TO CLOG.

POST THIS COUPON TODAY

To: **A. SCHRADER'S SON,** Air Control Products Dept. PE
829 TYBURN ROAD, ERDINGTON, BIRMINGHAM, 24

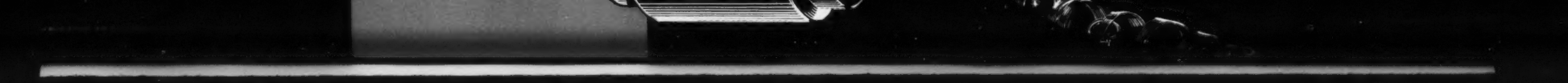
Please send details of Schrader Flow Control Valves

NAME .....

ADDRESS .....

.....

2



FROM STOCK

Have you tried Harris Tapping Lubricant? Available in 2 oz. (8d.) 7 lb. (13/3d.) and 28 lb. (47/-) packs.

HARRIS

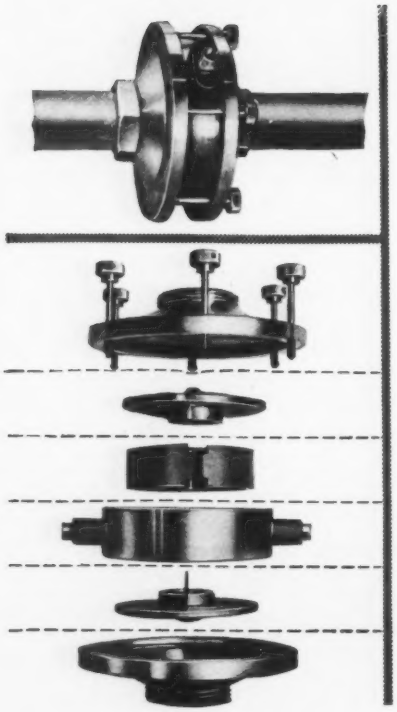
TAPS DIES AND GAUGES

JOHN HARRIS TOOLS LTD WARWICK

Simple or Complex...

MEASUREMENT METERS

suit every purpose



The new UNIPULSE all-purpose liquid meter designed by MEASUREMENT LIMITED is an important advance in accurate industrial metering of fluids in chemical compound manufacture, process engineering involving fluids, and food and drink production.

The UNIPULSE meter successfully operates with liquids varying in viscosity, acidity, alkaline content and temperature, and can be linked to a wide range of indicating or dispensing control devices.

The clean design eliminates the conventional gear mechanism, enabling fluids to be dispensed to an unprecedented accuracy.

Write to the Sales Manager, MEASUREMENT LIMITED for full particulars.

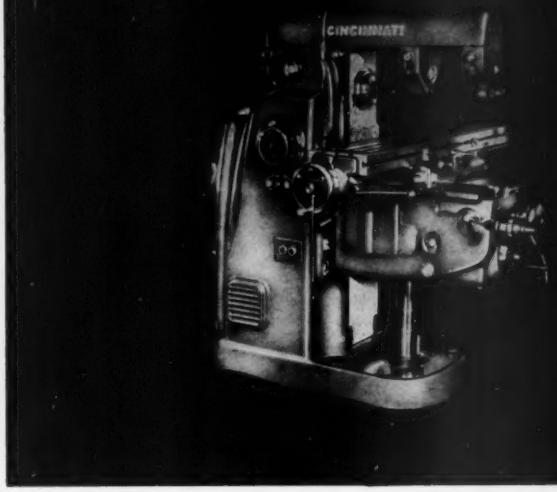
meters are matters for **MEASUREMENT**

MEASUREMENT LIMITED
P.O. Box No 2, Dobcross, Nr. Oldham, Lancs.
Tel : Delph 424 (5 lines) Telegrams: SUPERMETER, Dobcross

Export enquiries :
PARKINSON COWAN GROUP EXPORTS LIMITED
Terminal House, 52 Grosvenor Gardens, London, S.W.1.
Tel : Sloane 0111 Cables DISC, London.

A PARKINSON COWAN COMPANY

YOUR CHOICE

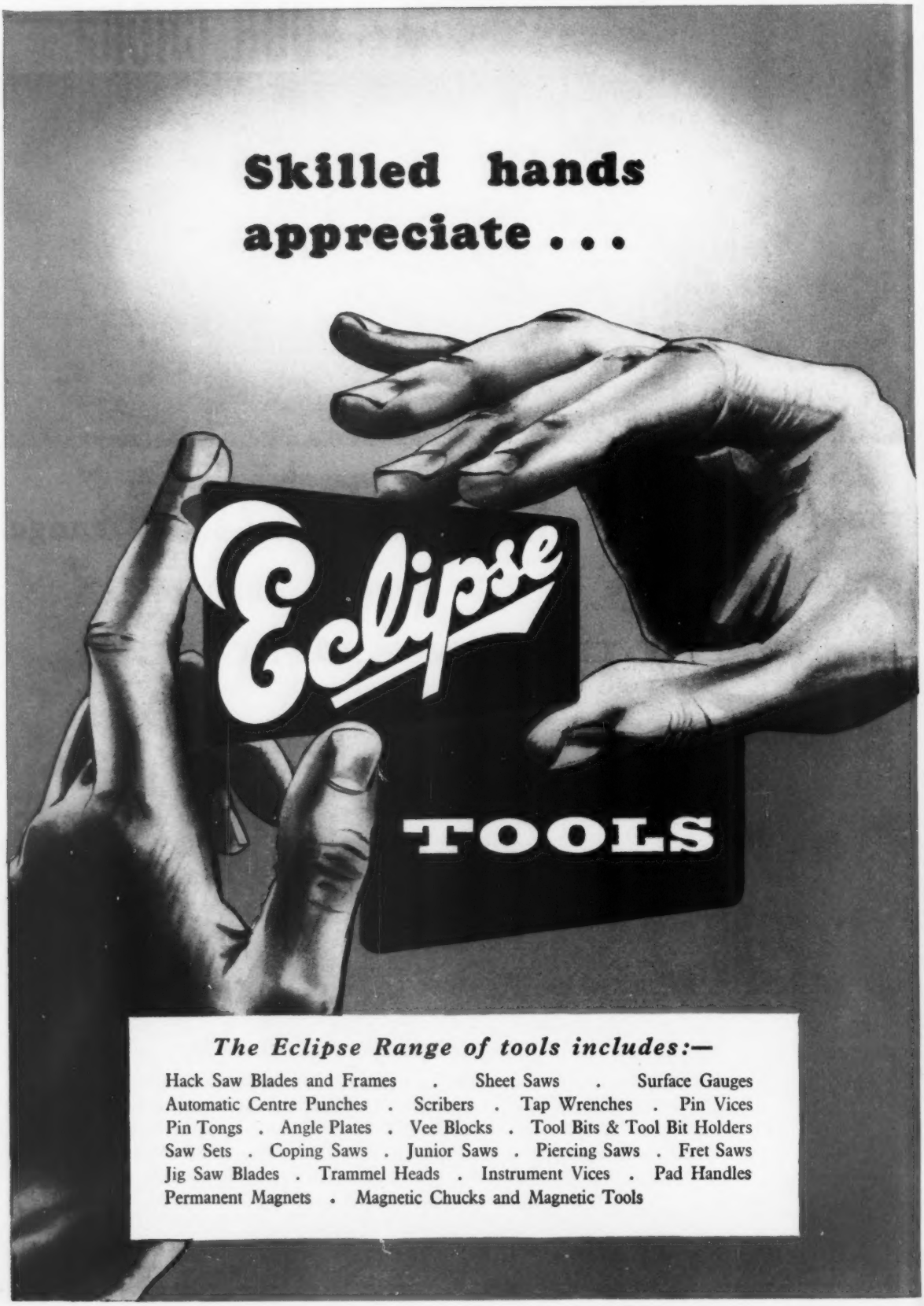


the comprehensive CINCINNATI range offers the choice of 23 general purpose

MILLING MACHINES

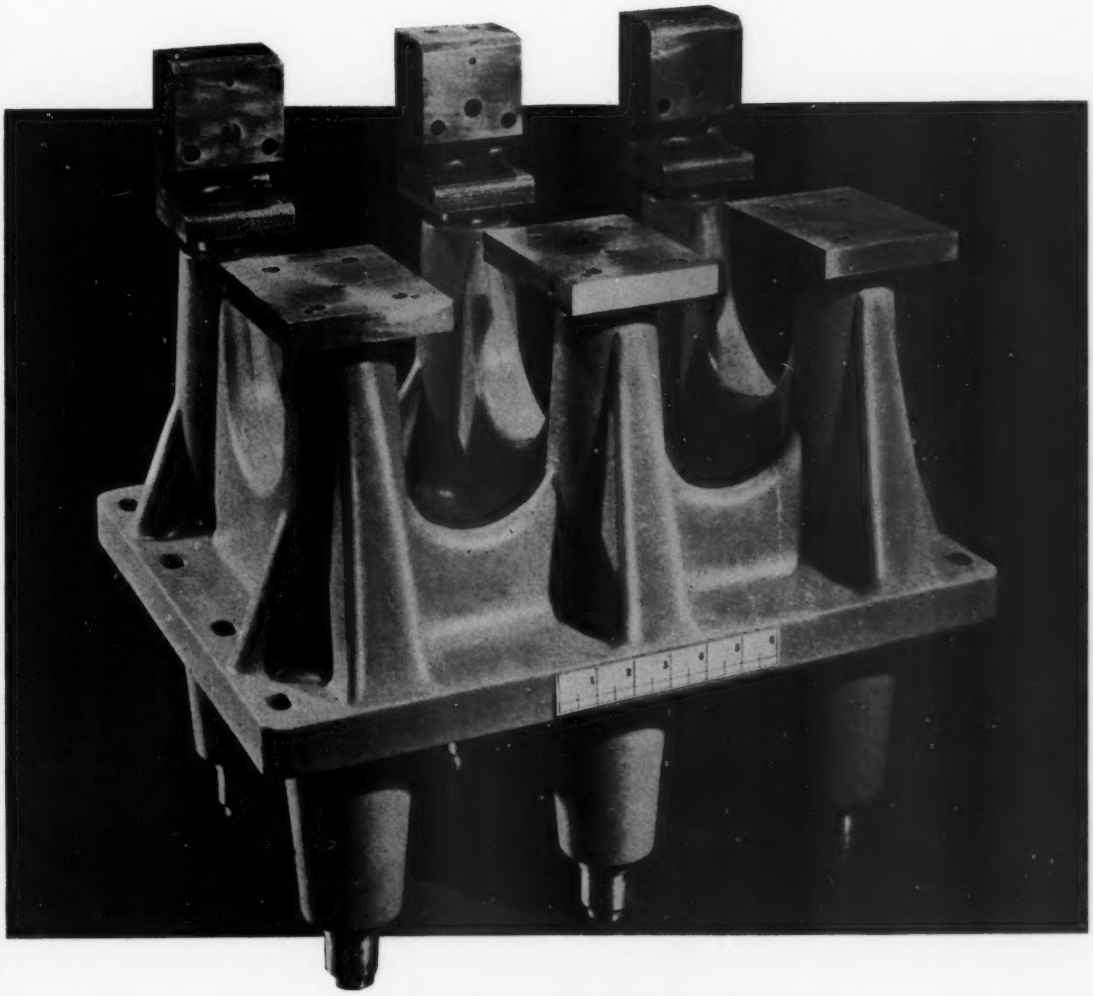
THROUGH

AGENTS: Chas. Churchill & Co. Ltd., London, Birmingham, Manchester, Gateshead, Glasgow


Skilled hands appreciate . . .
Eclipse
TOOLS
The Eclipse Range of tools includes:—
Hack Saw Blades and Frames . Sheet Saws . Surface Gauges
Automatic Centre Punches . Scribers . Tap Wrenches . Pin Vices
Pin Tongs . Angle Plates . Vee Blocks . Tool Bits & Tool Bit Holders
Saw Sets . Coping Saws . Junior Saws . Piercing Saws . Fret Saws
Jig Saw Blades . Trammel Heads . Instrument Vices . Pad Handles
Permanent Magnets . Magnetic Chucks and Magnetic Tools

Designed to use Araldite

By designing components to take full advantage of the qualities of Araldite epoxy resins, manufacturers are effecting great economies in cost and are increasing the technical efficiency of their products. The photograph shows an air-break switch backplate, moulded in Araldite by J. R. Ferguson (Electrical Engineers) Ltd., for the Federal Pacific Electric Company of Newark, New Jersey, U.S.A. It replaces a built-up component comprising a cast aluminium base plate, bored to take six paper bushings, which were individually clamped in position. Into the paper bushings six copper assemblies were then keyed, involving a considerable amount of fitting. The single Araldite moulding assembly, weighing approximately 200 lb., accomplishes all the above operations. With careful moulding technique, machining and fitting are both eliminated, whilst the Araldite moulding ensures higher impulse levels.



Araldite *epoxy resins*

Araldite is a registered trade name

CIBA (A.R.L.) LIMITED *Duxford, Cambridge. Telephone: Sawston 2121*

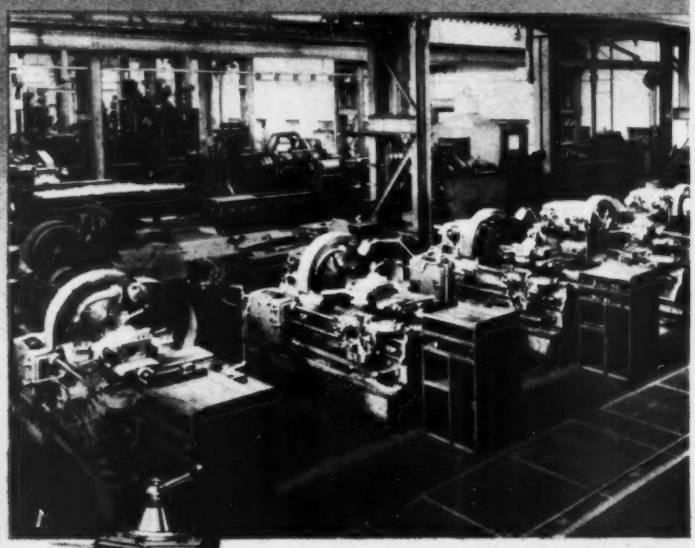
AP 533

D S G SURFACING & BORING LATHES

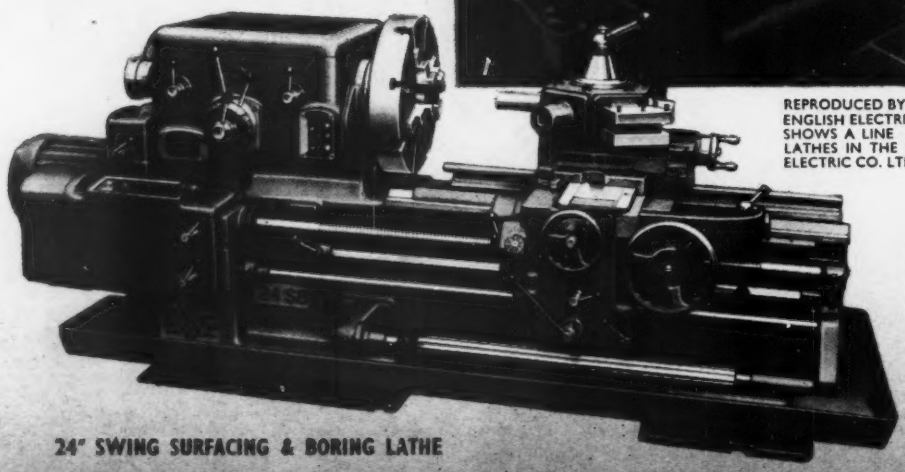
offer:- PRECISION FEATURES WHICH ARE PROVING THEMSELVES THROUGHOUT THE ENGINEERING INDUSTRY

FEATURES

- HIGH PRECISION INDEXING TURRET
- RAPID CENTRE POSITIONING WITH RETRACTABLE STOP
- COMPREHENSIVE RANGE OF TOOLHOLDERS INTERCHANGEABLE WITH OTHER MAKES OF TURRET LATHES
- AVAILABLE WITH GAPBED (NOT 13" LATHE)
- AMERICAN CAM-LOCK SPINDLE NOSE PERMITTING CONSISTENT AND RAPID REMOUNTING OF CHUCKS AND FIXTURES
- AUTOMATIC TRIPS TO LONGITUDINAL FEED FITTED AS STANDARD
- TRIPPING CROSS FEEDS AVAILABLE



REPRODUCED BY KIND PERMISSION OF THE ENGLISH ELECTRIC CO. LTD. ILLUSTRATION SHOWS A LINE OF SURFACING & BORING LATHES IN THE WORKS OF THE ENGLISH ELECTRIC CO. LTD. BRADFORD



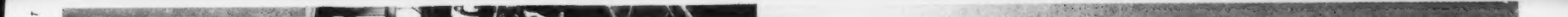
24" SWING SURFACING & BORING LATHE

MADE IN SIZES
13" TO 36"

Dean Smith & Grace
KEIGHLEY LIMITED ENGLAND

We manufacture: 13"—30" SWING CENTRE LATHES, COPYING AVAILABLE ON 13", 17", 21", 25", 26" & 30" SWING LATHES, TOOLROOM LATHES, 13"—36" SWING SURFACING & BORING LATHES

TELEX NO. 51-133 ● TELEGRAMS: LATHES KEIGHLEY TELEX ● TEL. NO. 5261 (7 LINES)



A REVOLUTIONARY STEP FORWARD

NO PUMP

NO FILTERS

NO PIPES

NO NOZZLES

BULLOWS **NOPUMP**

SPRAY BOOTH

ALMOST ENTIRELY ELIMINATES MAINTENANCE

NO PUMP
NO FILTERS
NO PIPES
NO NOZZLES

In this new type of Water-Wash Spray Booth the exhaust air travels at very high velocity over the water surface entraining water. The air/water mixture, moving through controlled changes of direction, provides the scrubbing action.

★ **A NEW PATENTED PROCESS OF WATER TREATMENT... SUBSTANTIALLY INCREASES THE EFFICIENCY OF THESE BOOTHS.**

A. BULLOWS & SONS LTD · LONG ST · WALSALL · STAFFS · TEL: 5401

Visits to factories where Bullows NOPUMP Booths have been installed can be arranged on request.

Complete the reply-paid postcard alongside and post today for full details of this outstanding Bullows' achievement.

Please post full details of your NOPUMP Spray Booths.

Please arrange for a representative to call with full details of your NOPUMP Spray Booths.

(DELETE WHICHEVER IS NOT REQUIRED)

Name (BLOCK CAPITALS PLEASE) .....

Position .....

Company & Address .....

.....

.....

To: A. BULLOWS & SONS LTD . LONG STREET . WALSALL . STAFFS . Tel: 5401

NO PUMP

NO FILTERS

NO PIPES

NO NOZZLES

IN WATER-WASH SPRAY BOOTHS

NO CLEANING OUT AFTER 1 YEAR'S CONTINUOUS DOUBLE-SHIFT WORK

AT

Massey-Ferguson
(UNITED KINGDOM) LTD.

STRETFORD
MANCHESTER

NO PUMP

NO FILTERS

NO PIPES

One of the early NOPUMP Booths installed is the 22 ft. 6 in. long × 13 ft. 6 in. wide downdraught Booth at Massey-Ferguson (United Kingdom) Ltd., Stretford, Manchester.

This Booth was started up on production on 1st March, 1959, and ever since has operated two nine-hour shifts on continuous painting of agricultural machinery.

When last examined, there was an average depth of silt of 6 inches over the entire water tank bottom, an area of 290 sq. feet. A further 4 inches, making 10 inches in all, can be accommodated before cleaning is essential. The fan and ducting are barely discoloured. The only maintenance cost has been cleaning the floor inside the booth and routine greasing of bearings, checking and adjusting belts and similar routine preventive maintenance.

Postage will be paid by Licensee

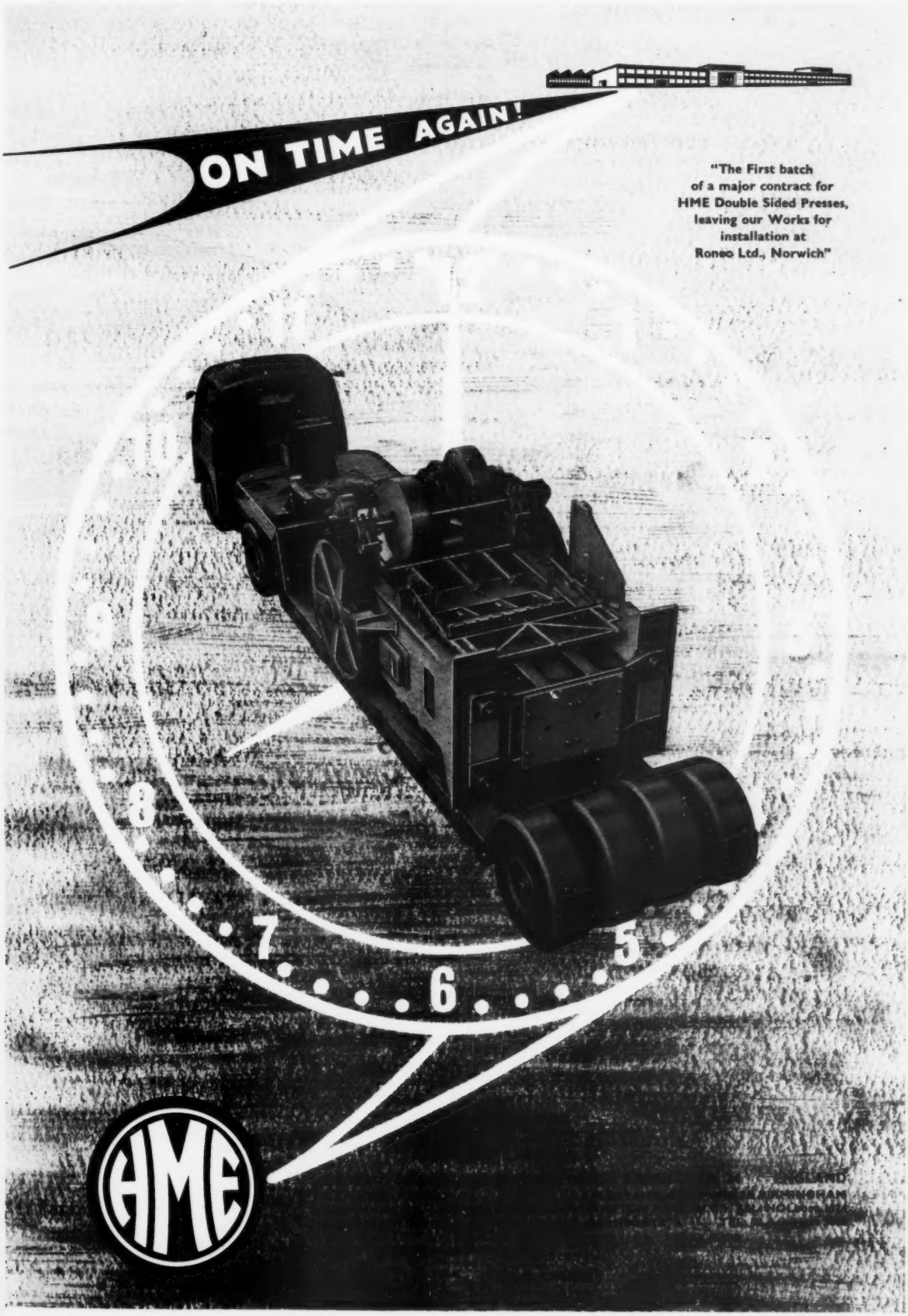
No Postage Stamp necessary if posted in Great Britain or Northern Ireland

BUSINESS REPLY CARD
Licence No. W.L.69

A. BULLOWS & SONS LTD.
Long Street,
WALSALL, Staffs.

BULLOWS NOPUMP BOOTHS ALSO INSTALLED AT-

Audley Engineering Co. Ltd., Newport, Salop.
The Austin Motor Co. Ltd., Longbridge.
Besfoldas Ltd., London, S.E.15
B.X. Plastics Ltd., London, E.4.
Laconite Ltd., Walton-on-Thames.
K.F. Creffield & Co. Ltd., Southall.
Duroglass Ltd., London, E.17.
Electroway Heaters Ltd., Loughborough.
English Rose Kitchens Ltd., Warwick.
Gross Cash Registers Ltd., London, N.8.
Harris & Sheldon Ltd., Birmingham.
Holmes Bros. (London) Ltd., London, E.10.
Ideal Casements (Reading) Ltd., Reading.
William A. Lewis (Shrewsbury) Ltd., Shrewsbury.
W. Lucy & Co. Ltd., Oxford.
Midland Industries Ltd., Wolverhampton
Murex Welding Processes Ltd., Waltham Cross.
Owen & Randall (Stor Cabinets) Ltd., Maidenhead.
Platt Bros. & Co. Ltd., Oldham.
Rolinx Ltd., Manchester.
Shuresta (A. Mirecki) Ltd., Coventry.
T. Wall & Sons (Ice Cream) Ltd., Gloucester.
Wilkins & Mitchell Ltd., Walsall.


ON TIME AGAIN!
"The First batch of a major contract for HME Double Sided Presses, leaving our Works for installation at Roneo Ltd., Norwich"
HME

IN THE BAG with R.O. pallets.

R. & J. Garroway Ltd., of Glasgow, know from experience that the most efficient and economical way of handling the bagged fertiliser which they manufacture is to use R.O. pallets with their Conveyancer Fork Trucks*. That is why they have recently ordered a further 700 all welded pallets with collapsible posts and slotted all steel decks. Storage of pallets not in use takes up minimum space, an all important factor when a trade is seasonal.

No matter what product you handle, the Rubery Owen palletisation service can provide a practically designed pallet, perfect for the job. Get in touch with us now for quicker, safer, cheaper, handling.

TECHNICAL DATA

The pallets are of a sturdy, robust mild steel all welded construction. The overall size of the assembled pallet is 48" × 60" × 54¼" high, but for storage purposes with posts removed the size becomes 48" × 60" × 8¾" high, approximately an 85% saving on storage space for each pallet. The capacity of each pallet is 30 cwt. evenly distributed and they are stackable up to 4 high.

* Made by another member of the great Owen Organisation

RUBERY OWEN PALLETS

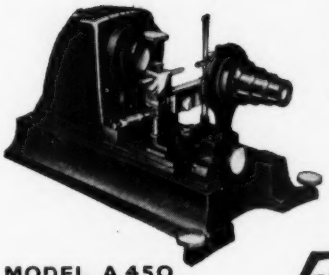
RUBERY OWEN & CO LTD · INDUSTRIAL STORAGE EQUIPMENT DIVISION
WHITEGATE FACTORY · WREXHAM · N. WALES · TELEPHONE: WREXHAM 3566/8

VISIT OUR STAND No. J.15 AT THE MECHANICAL HANDLING EXHIBITION MAY 4-14

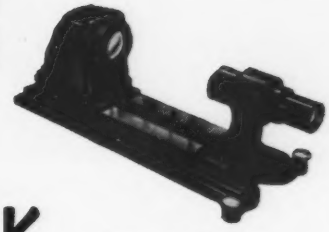
MEASUREMENT BY PROJECTION THE Shadomaster WAY REGD

ensures

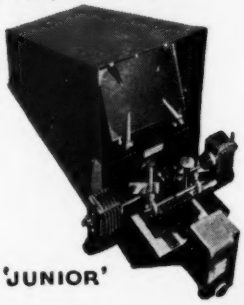
TRUE-GAUGE PROJECTION OF SUPREME OPTICAL ACCURACY ECONOMICALLY



MODEL A 450

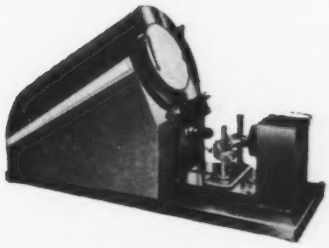


MODEL C 900



THE 'JUNIOR'

The "Shadomaster" True Gauge Projector range includes self-contained vertical and horizontal cabinet projectors providing magnifications from 10x to 250x and independent projectors operating with large working fields up to 6 in. dia., covering virtually every requirement in optical inspection methods.



THE 'MINOR'

IMMEDIATE DELIVERY OF ALL TYPES FROM STOCK

MODEL CRP MKII

THE 'MAGNUM'

BUCK & HICKMAN LTD.

FULLY DESCRIPTIVE BROCHURE FROM DISTRIBUTORS

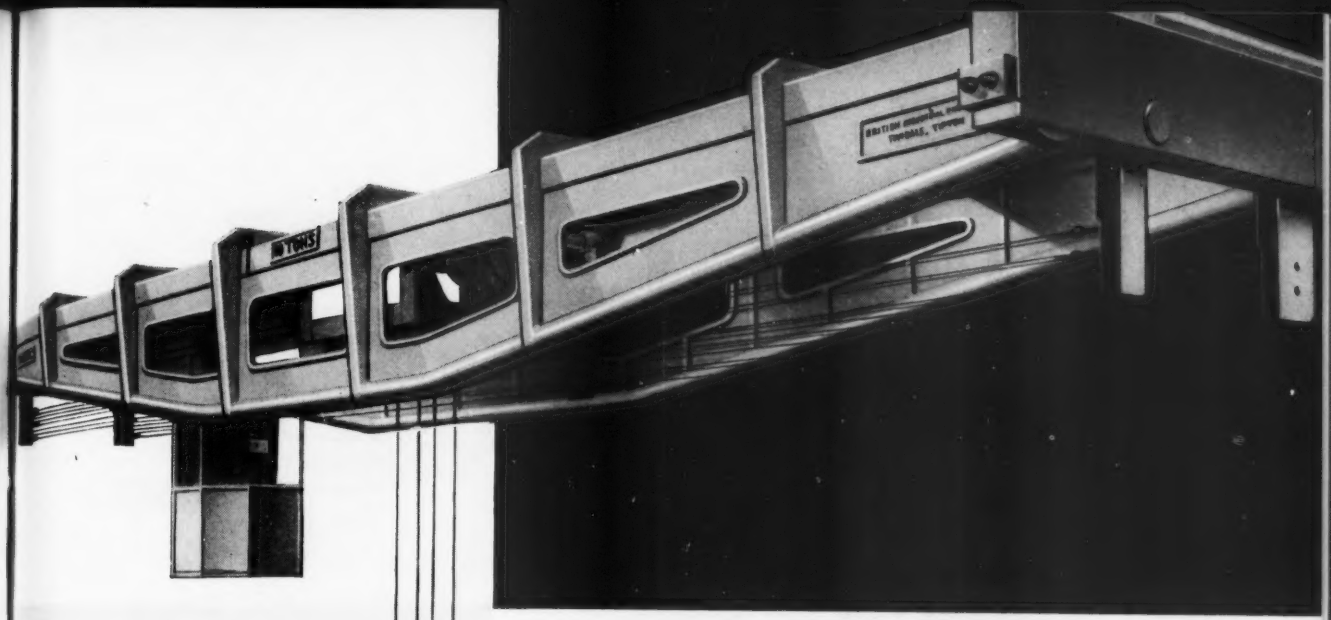
OTTERSPOOL WAY · WATFORD BY-PASS · WATFORD · HERTS.

OR BRANCHES AT ALPERTON · BIRMINGHAM · BRISTOL · GLASGOW · LEEDS · MANCHESTER

There is a tide in the affairs of every business. There comes a moment when you *must* expand if you're to keep pace with your competitors. That's where UDT comes in. UDT helps you replace old equipment, add new, out of income. Which often means it pays for itself out of increased profits. A nice businesslike way to do business. If you think UDT could help you, get in touch with the Manager of your nearest UDT office—the address is in your local directory.

United
Dominions Trust
(Commercial)
Limited

United Dominions House
Eastcheap, London EC3



Manufactured under licence from Ferrand & Frantz Ing. Villeurbanne.
British Patent No. 705,148.

BUSINESS IS LOOKING UP -WITH REEL OVERHEAD

The remarkable performance of REEL overhead cranes has been proved conclusively on hundreds of installations. The new approach to overhead crane design has put REEL well ahead. Conventional boxed lattice frames have been replaced by clean-lined girders providing greater strength and lightness, with a consequent saving in power consumption. REEL Cranes can be carried to within two or three inches of the roofwork and are in capacities to suit your individual requirements.
Full information on request.

THE BRITISH

"REEL"

OVERHEAD CRANE

BRITISH INDUSTRIAL

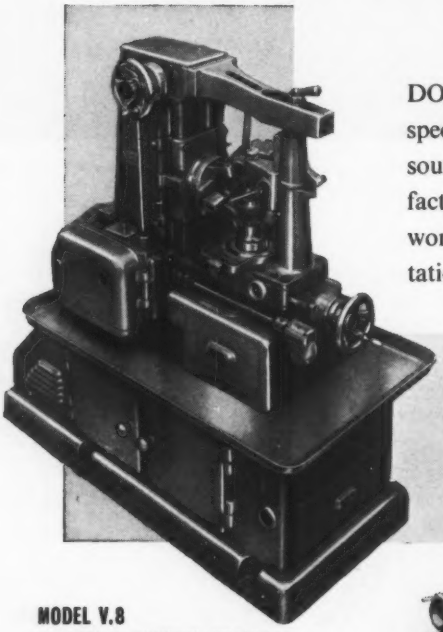
ENGINEERING COMPANY (STAFFS) LIMITED

Coronation Works, Hainge Road, Tividale, Tipton, Staffs. Telephone: TIPTON 1222/3/4

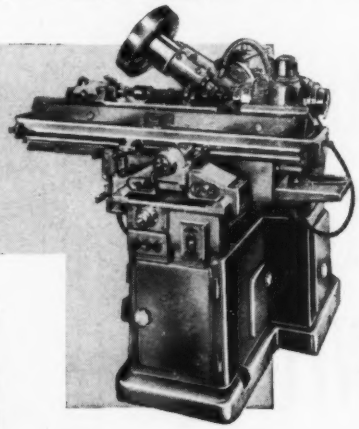
HOBBING

–it pays to investigate

BRITISH-BUILT DOWDING

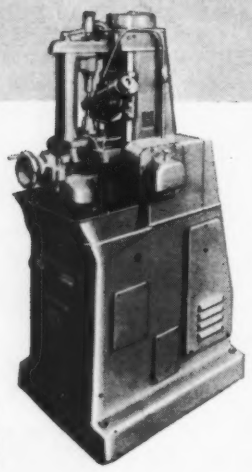


DOWDING Hobbers have been developed by gear specialists: their accuracy and economy are the result of sound basic design coupled with craftsmanship in manufacture. They are to be found in leading engineering workshops throughout the world, earning a high reputation for their accuracy and dependability.



MODEL V.8
UNIVERSAL HOBBING MACHINE

Accurate, versatile, economical. With built-in differential. For spurs, helicals, wormwheels, and worms. Tangential feed and cam operated plunge feed are optional extras. Maximum dia. 8", 7" Face. 12 D.P.



MODEL V.4
UNIVERSAL HOBBING MACHINE

Accurate, rigid, and versatile. With built-in differential. For the smaller spurs, helicals, worm wheels, and worms used in light engineering and instrument work. Tangential feed is also available.
Up to 4" Diameter, 4" face, 20 D.P.

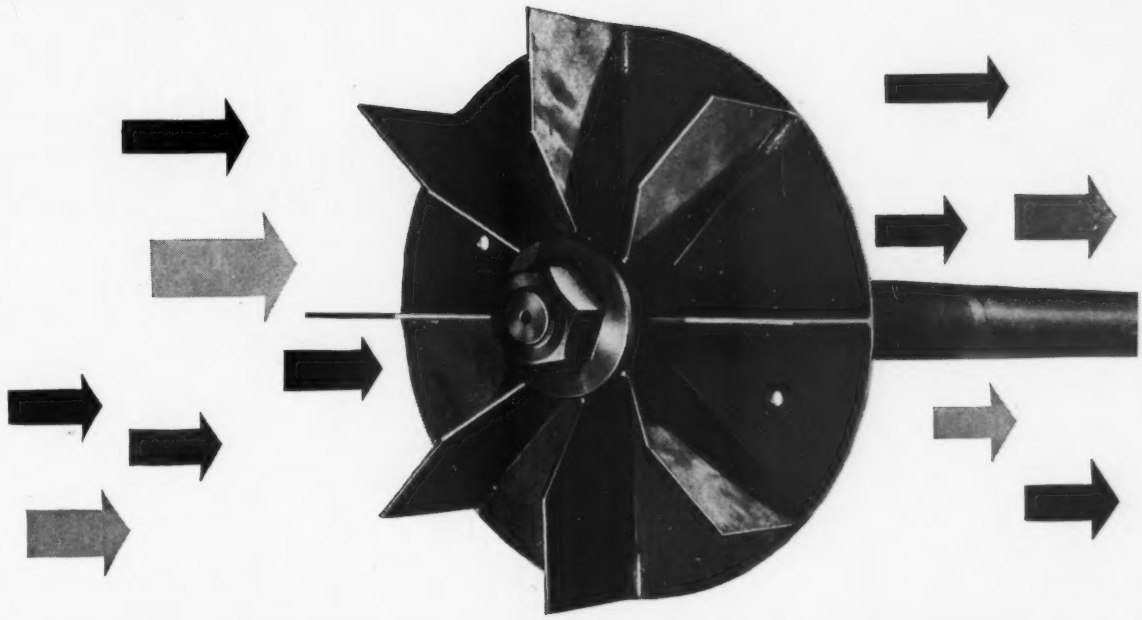
MODEL H.7
HORIZONTAL HOBBING MACHINE

Powerful and rigid. With built-in differential. For long splines and gears integral with long shafts, and parallel and taper serrations. Alternative heavy duty or high helix angle hob heads. Maximum dia. 7". Hobbing length 18". 8 D.P.

Ask us to send our new illustrated Hobbing brochure

DOWDING & DOLL LTD
346 KENSINGTON HIGH STREET, LONDON, W.14
Telephone: WESTERN 8077 (8 lines) *Telegrams*: ACCURATOOL HAMMER LONDON

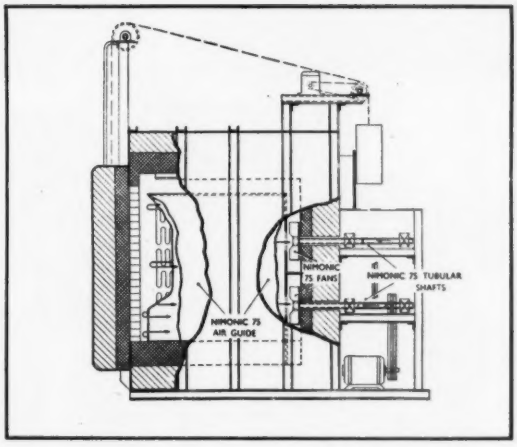
128



For furnace fans operating at 1100° C

-Nimonic* 75

HEAT-RESISTING ALLOY



A high-temperature electric furnace of advanced design has been developed by Hedin Limited, for the heat-treatment of components during the overhaul of Rolls-Royce 'Avon' and 'Conway' turbo-jet engines.

To ensure even heat distribution within the furnace, four centrifugal fans are required to operate continuously at temperatures up to 1100°C. The nickel-chromium alloy, Nimonic 75, was selected for the construction of the fans and their drive shafts. The excellent high-temperature properties of Nimonic 75 enable it to resist oxidation and withstand the exacting centrifugal stresses at extreme heat.

TOP
In addition to the forced-circulation fans and drive shafts, Nimonic 75 is used for the air-guide furnace liner which directs circulating air over the heating elements.

INSET
Diagram shows forced-circulation system and the Nimonic 75 hollow fan-shafts cooled by compressed air.

* Trade Mark

SEND THIS COUPON

for a specimen copy of 'WIGGIN NICKEL ALLOYS'

NAME_____

APPOINTMENT OR DEPARTMENT_____

COMPANY AND ADDRESS_____

_____ PE/H16/4

HENRY WIGGIN & COMPANY LIMITED · WIGGIN STREET · BIRMINGHAM 16

TGA H16

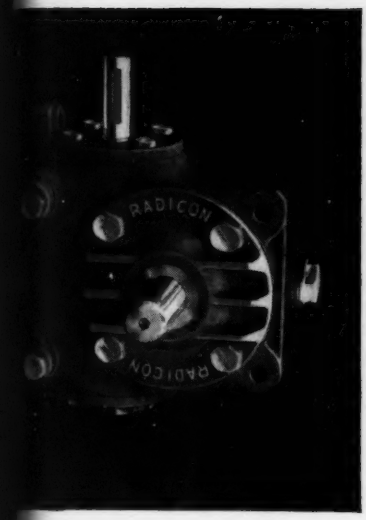
This is the thumb that starts the machine that cuts gears faster than any other machine in the world

Whose thumb is it? It could be anyone's. The ownership of the thumb is unimportant. It's the ownership of the machine that counts. For the machine is a Hydrax — the world's most advanced gear hobber. Anyone who owns a Hydrax cuts gears at an astonishing speed — automatically — accurately. Hydrax hobbing means multi-spindle production from a single-spindle machine. If you really want to get hobbing, you'll want information about the Hydrax range. We'll be glad to send you literature.

DAVID BROWN

THE DAVID BROWN CORPORATION (SALES) LIMITED

MACHINE TOOL DIVISION, BRITANNIA WORKS, SHERBORNE STREET, MANCHESTER 3. TELEPHONE: MANCHESTER BLACKFRIARS 4711



SPEED REDUCERS . . .

. . . trouble free whichever way you look at them

For efficient, trouble-free speed reduction you can rely on a Radicon. These compact, efficient reduction units can be mounted in almost any position to do almost any kind of job. And once mounted, they run with the minimum of attention. You have a choice of 40 alternative mounting positions and of 64 ratios ranging from 5 : 1 to 3600 : 1. But to learn full details, you'll need our Catalogues Nos. E 387-96 and E 387-108. We'll be glad to send you copies.

DAVID BROWN

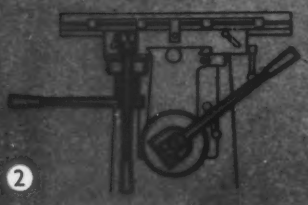
THE DAVID BROWN CORPORATION (SALES) LIMITED.

LONDON GEAR DIVISION, STONEBRIDGE PARK WORKS, NORTH CIRCULAR RD., LONDON, N.W.10
TEL.: ELGAR 6824

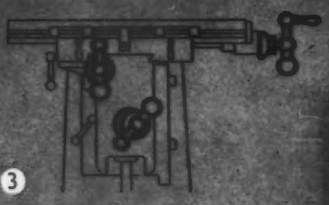
6 × 4 = 24

TYPES OF FEED | SPEED RANGES | POSSIBLE COMBINATIONS

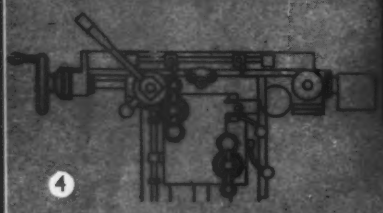
1 Hand Feed—lever, screw, lever.



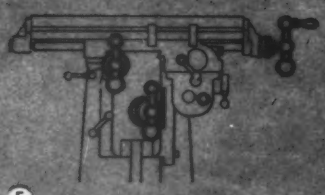
2 Hand Feed—lever, lever, lever.



3 Hand Feed—Screw, screw, screw.



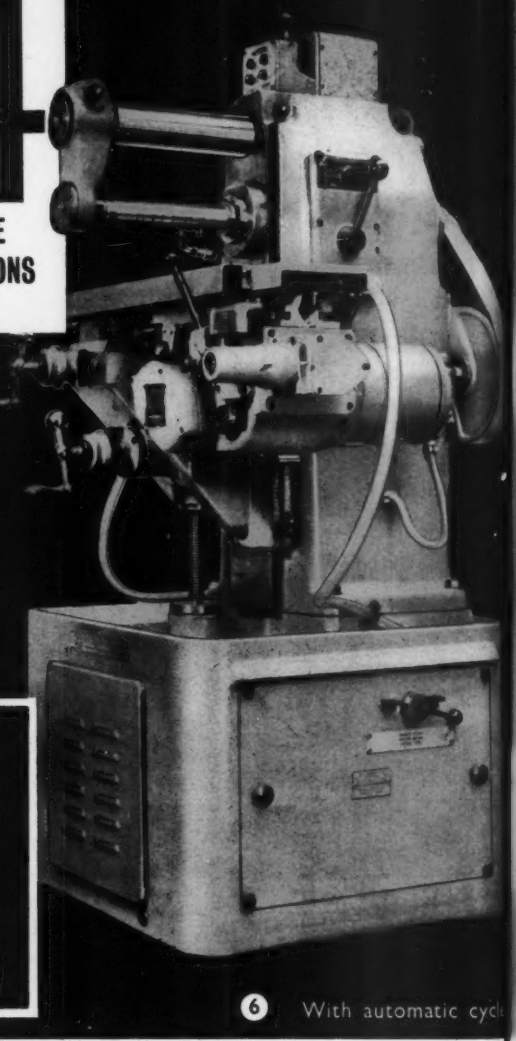
4 Multiform—semi-automatic cycle.



5 Normal automatic feed.

that's the beauty of the

A&S MODEL 'I' HORIZONTAL MILLER



6 With automatic cycle

WHY PAY FOR 'SPECIAL' FEATURES YOU MAY NEVER USE?

When you equip with A & S Model 'I' Millers you choose from 4 ranges of speeds and 6 different feed arrangements the best combination* for a particular job. Both hand-feed and automatic types can however be supplied with special attachments for special operations. No other small milling machine offers similar versatility or higher production capacity for so wide a range of work.

TABLE 26" × 7"
LONGITUDINAL TRAVERSE = 10"
VERTICAL TRAVERSE = 10"
TRANSVERSE TRAVERSE = 5¼"-6"

**With the A & S Model 'I' brochure in front of you, you would know exactly what we mean.*

Built up to a standard-not down to a price

Write for illustrated leaflet

ADCOCK & SHIPLEY LTD

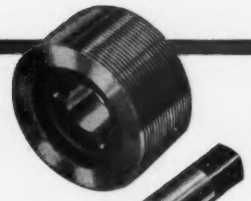
P.O. Box 22, Ash Street, Leicester. Telephone: Leicester 24154-6. Telegrams & Cables Adcock, Leicester.

International Machine Tool Exhibition OLYMPIA 1960 June 25 - July 8

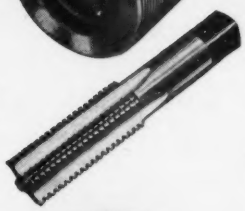
MATRIX COVENTRY GAUGE & TOOL COMPANY LTD QUALITY

Thread Grinding Machines

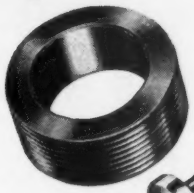
save money on parts like these



Screw Plug Gauge
2¾" dia. x 11 T.P.I. x 2¼"
Whitworth Form

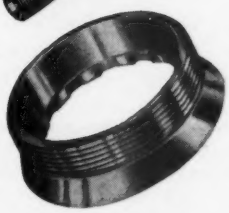


High Speed Steel Tap
1" x 8 T.P.I. x 2½"
Whitworth Tap
Limits BS949
Grinding Time 80 secs.



Thread Crushing Roller
3" dia. x 8 T.P.I. x 1⅛"
American Form

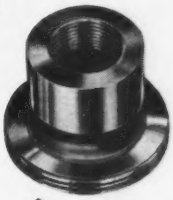
Micrometer Screw
10mm.x0.5mm.x40mm.
long, S.I. Form
Grinding Time 6 mins.



Internal Combustion
Engine Valve Seat
1¾" dia. x 20 T.P.I. x ⅝"
Whitworth Form
Grinding Time 50 secs.

The various 'MATRIX' Models represent the world's widest range of Thread Grinding Machines.
They will accommodate a range of work extending from the finest threads used in precision instrument manufacture up to a maximum capacity of 14" diameter by 72" long.
The machines embody the latest advances in toolroom and production thread grinding technique and are based on many years of research and development.

Steering Worm
26mm. x 6mm. x 66 mm. long
L.H. Worm Form
Grinding Time 3 mins.



Internal Threaded Component
1½" dia. x 16 T.P.I. x ½" Unified Form
Grinding Time 4 mins.

Screw Plug Gauge
1½" dia. x 4 T.P.I. x 2" Acme.

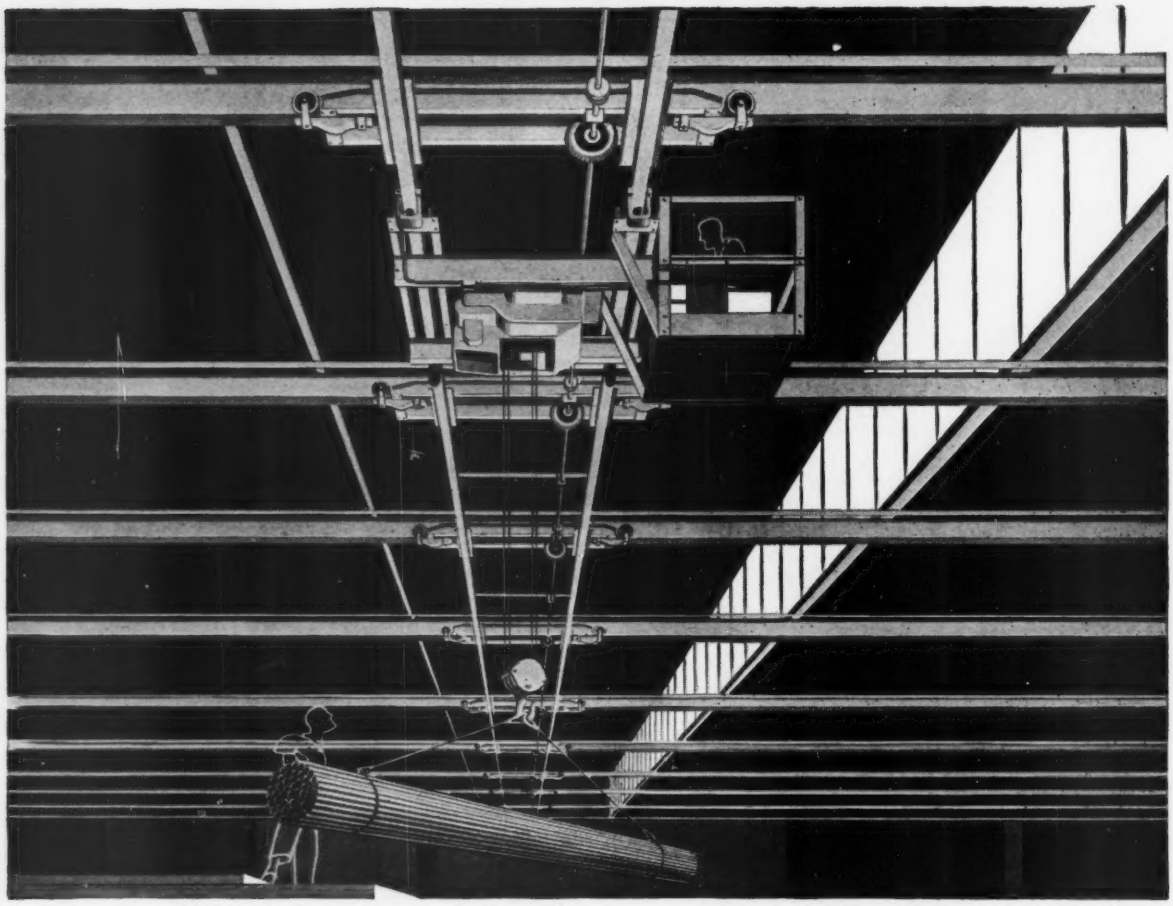
ROCKWELL MACHINE TOOL CO. LTD.

For further particulars write or telephone TODAY

WELSH HARP, EDGWARE RD., LONDON, N.W.2.
TEL: GLADSTONE 0033

ALSO AT BIRMINGHAM—TEL: SPRINGFIELD 1134/5 • STOCKPORT—TEL: STOCKPORT 5241 • GLASGOW—TEL: MERRYLEE 2822

Matrix 7



One overhead crane serves 40,000 sq. ft. with loads of up to 5 tons

After a survey of your plant, we produce a tailor-made plan. This and the estimate are free.

Areas of almost any size, with a span of up to 200 feet, can be served with a single long span Underslung Crane from British MonoRail. Loads of up to 5 tons can be moved with precision to any point in any place within a factory's cubic area. These long span cranes need little headroom, and are light and flexible to handle. Their versatility and power of coverage lift awkward handling problems of every type from the factory floor.

More advantages of MonoRail Underslung Cranes. All materials and track specially developed for the job. Rubber-tyred crane drive eliminates track wear. Standard track flange width. Wide range of interlocks, switches and lifts gives free flowing movement in all directions.

A complete Overhead System. Long span Underslung Cranes are only part of the complete MonoRail handling and transfer system which can be tailored for every need, and which will enable the load to be transferred beyond the crane area to any part of the factory.

IF YOU WANT TO GET A MOVE ON

Send for the man with the MONORAIL plan

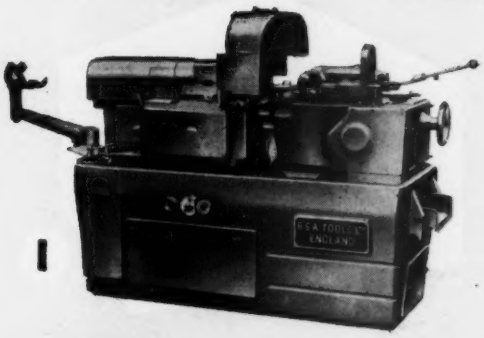
BRITISH MONORAIL LIMITED · WAKEFIELD ROAD · BRIGHOUSE · YORKS · TELEPHONE: BRIGHOUSE 2244

A member of the Herbert Morris Group of Companies

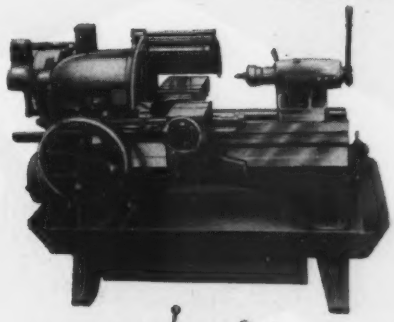
TGA 8M6

the B·S·A range

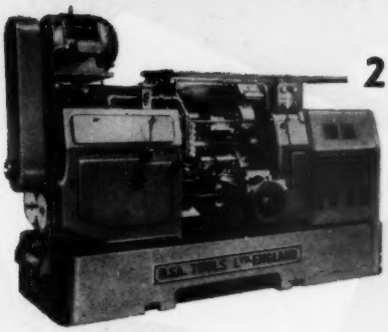
of high-production machine tools



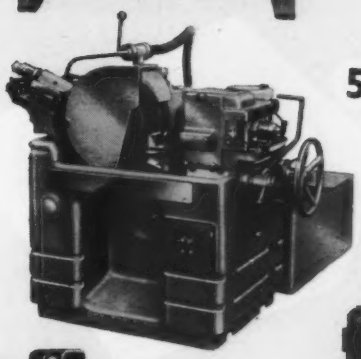
1



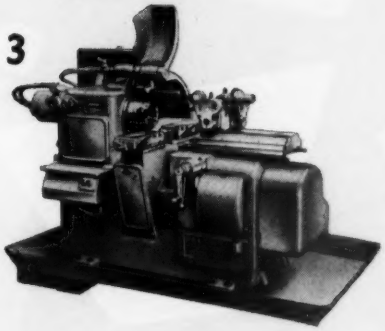
4



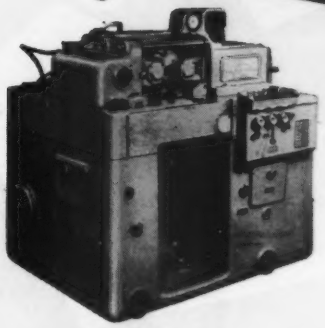
2



5



3



6

7

1. **SINGLE - SPINDLE AUTOMATIC SCREW MACHINES** in a range of sizes to 2in. diameter capacity, including **SIMPLIFIED** machines.
2. **B.S.A. ACME - GRIDLEY BAR AUTOMATICS,** 4, 6 and 8 spindle machines in various sizes up to 3½in. diameter capacity, and **CHUCKING** Six-spindle 6in. and 7½in. diameter capacity.
3. **SINGLE - SPINDLE CHUCKING AUTOMATICS,** 7½in. and 12½in. swing. Also B.S.A. P & J Turret Lathe 30in. swing.
4. **MULTI - TOOL PRODUCTION LATHES,** 6in. × 20in. and 28in., and 6in. **HYDRAULIC COPY TURNING LATHE.**
5. **CENTRELESS GRINDING MACHINES,** No. 4. up to 3in. diameter, and No. 8, up to 6½in. diameter capacity.
6. **FORM GENERATOR,** ⅛in. to 3in. diameter capacity and **THREAD GENERATING MACHINE,** 2 B.A. to ⅝in. B.S.F.
7. **AUTOMATIC TAPPING MACHINES,** ¼in. to 1¼in. diameter capacity (in steel).

Also Broaching Machines, Tool Holders, Tools, Attachment and Special Equipment.

TRADE MARKS B·S·A TOOLS

A.D. No. 433

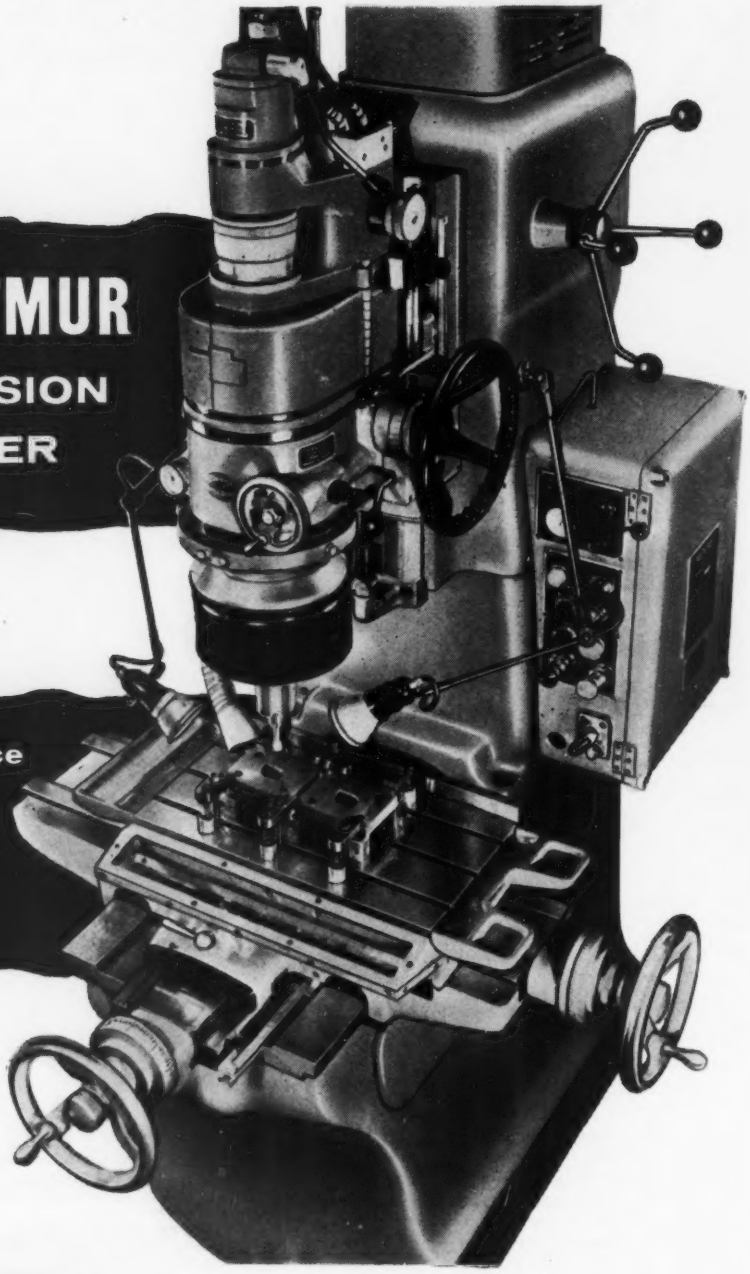
B.S.A. TOOLS LTD • BIRMINGHAM 33 • ENGLAND

SOLE AGENTS U.K. BURTON GRIFFITHS & CO LTD · MACKADOWN LANE · BIRMINGHAM 33 · STEchford 3071

the ultimate in **JIG GRINDING**

MOORE-CATMUR

No. 2 PRECISION JIG GRINDER



The craftsman's choice —for high precision and rapid stock removal.

The dust protective aprons have been removed for the actual photograph.

INTERNATIONAL MACHINE TOOL EXHIBITION 1960
Olympia - London June 25 - July 6
STAND No. 424
NATIONAL HALL GALLERY

CATMUR MACHINE TOOL CORPORATION LIMITED

103 Lancaster Road, Ladbroke Grove, London, W.11. 'Phone PARk 9451/2

MRP 2631

TELESIG Screw Pumps are positive displacement pumps. Simply constructed, they offer exceptional performance and long life. TELESIG pumps effect delivery by means of three parallel screws engaging each other, the power-driven central screw driving the two side screws. They may be run at high speed thereby reducing motor sizes and installation costs.

TELESIG Screw Pumps offer the following advantages:

- Self priming.
- Delivery free from pressure pulsation.
- High working speed — small size.
- Near-silent operation.
- Simple construction.
- Minimum maintenance and easy replacement of working parts.
- Long life.

TELESIG Screw Pumps are made in three basic ranges: for low pressures up to 300 psi, for medium pressure up to 1000 psi and for high pressures up to 2,500 psi. 42 sizes are available covering a wide range of capacities.

TELESIG

Screw Pumps by Telehoist

TELESIG pumps and equipment are made by Telehoist under licence from the Swiss Industrial Company (SIG).

Telehoist Limited. Cheltenham England. Telephone: Cheltenham 53254

an associate company of Wilmot Breeden Ltd.

First Choice for Gang milling

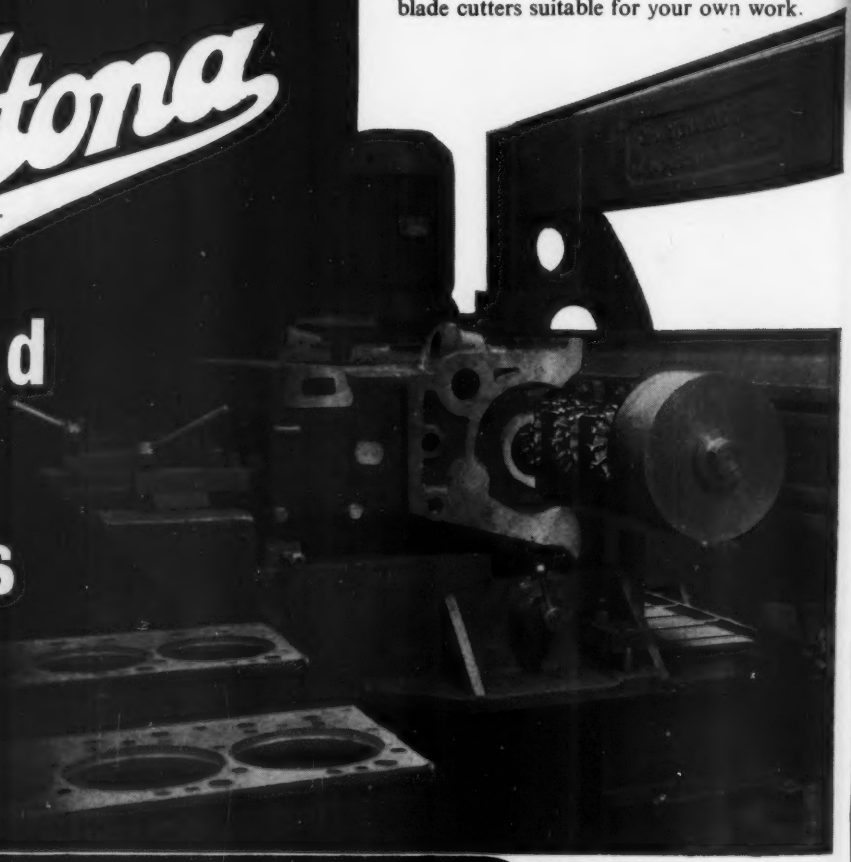
Albion Motors Ltd., Glasgow, have proved on production that GALTONA serrated blade cutters have all the attributes of successful gang milling .... uniformity of performance, high cutting power and long life.

Our illustrations show the milling of journal faces on 6-cylinder engine cylinder blocks. The twelve 6 in. diameter cutters finish the job at one pass.

Ask for details of GALTONA serrated blade cutters suitable for your own work.

Galtona TRADE MARK

serrated blade cutters

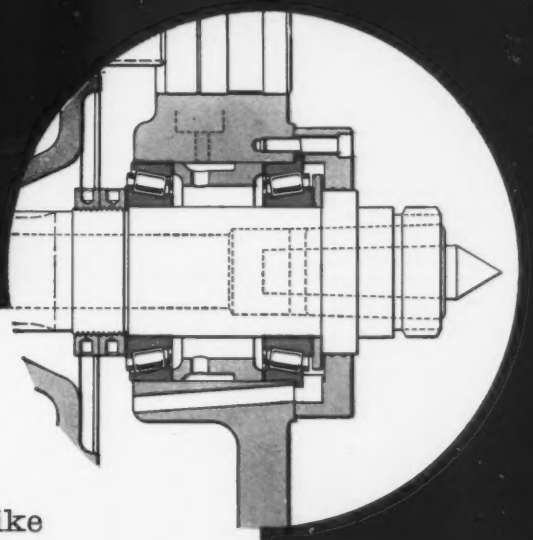


Richard Lloyd Limited

GALTON HOUSE, ELMFIELD AVENUE, TYBURN, BIRMINGHAM, 24

Telephone: Ashfield 1801, Telegrams "Cogs, Birmingham"

NORTHERN AREA A. V. Green, Britannia House, Wellington St., Leeds 1. Tel. Leeds 21212
NORTHERN IRELAND Garage & Engineering Supplies Ltd., 78 Great Victoria St., Belfast
LONDON AREA A. J. Percy, 240 Romford Rd., Forest Gate, Tel. MARyland 7304/5
SCOTLAND: Stuart & Houston, 5 York St., Glasgow, C.2.



TWELVE-INCH SWING LATHE made by

T. S. Harrison & Sons Ltd., Heckmondwike

This high-class lathe has many interesting features: it is available either as a standard centre lathe, or as a copying lathe without restriction of its normal use. The all-geared headstock is driven through a specially designed clutch which, with the brake, is operated by a lever on the headstock. The main spindle is bored to clear a 1¼" bar and is mounted at the front end in a pair of Timken tapered roller bearings.

The line drawing shows the bearing arrangement: a shouldered Timken bearing is held axially by the bearing cap and controls the end location of the spindle. The bearings are pre-loaded by the ring nuts on the spindle. The tail end of the spindle is supported in a ball bearing having axial freedom. As will be seen, the bearing arrangement permits the boring of both bearing seatings together, ensuring concentricity.

Other Harrison lathes, and milling machines, are also equipped with Timken bearings.

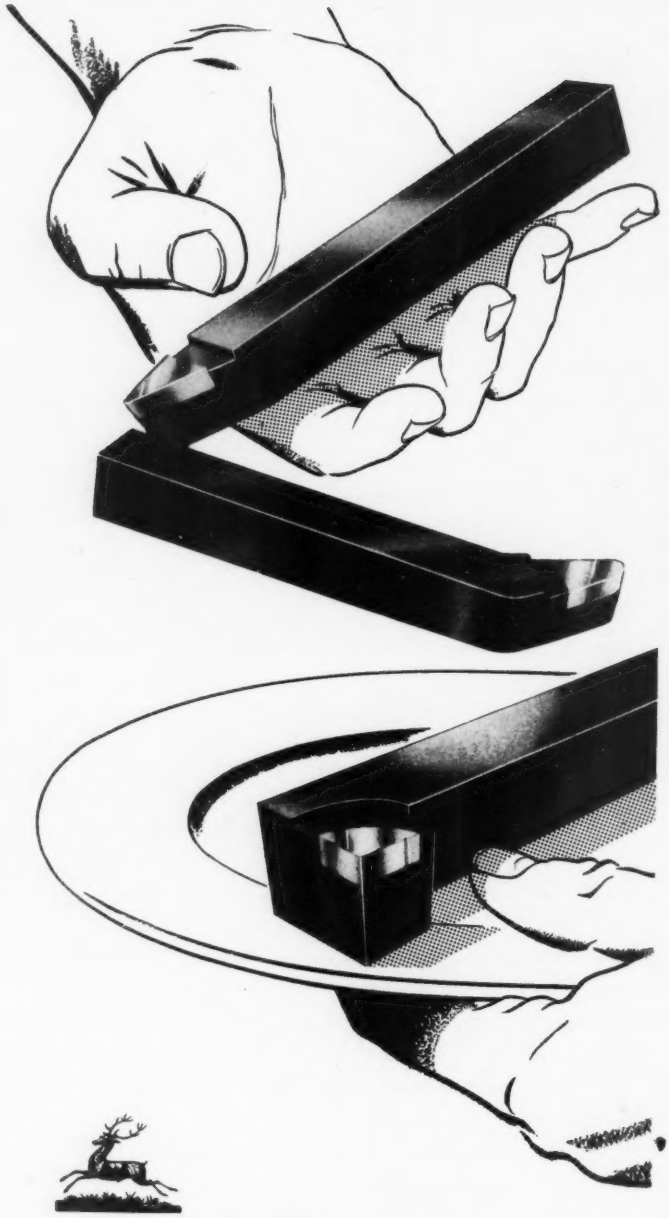
British Timken, Duston, Northampton, Division of The Timken Roller Bearing Company. Timken bearings manufactured in England, Australia, Brazil, Canada, France and U.S.A.

TIMKEN®

REGISTERED TRADE-MARK

tapered roller bearings

We like to tip well . . .



Stag Allenite tipped cutting tools afford you the greatest production output in metal machining. Highest cutting speeds combined with very long life between grinds are attainable where conditions are favourable to this type of cutting edge—a tip of extremely hard tungsten carbide, brazed to a high grade shank.

Recent developments in Stag Allenite applications include the amazing 'PLOW-RAKE' tools for high-speed heavy-duty planing of steel and 'PLOWCAST' tools for planing cast iron and non-ferrous metals; both tools are particularly useful where interrupted surfaces occur.

Write for full information about Stag Allenite and our other cutting tools.

STAG ALLENITE
Tipped Cutting Tools

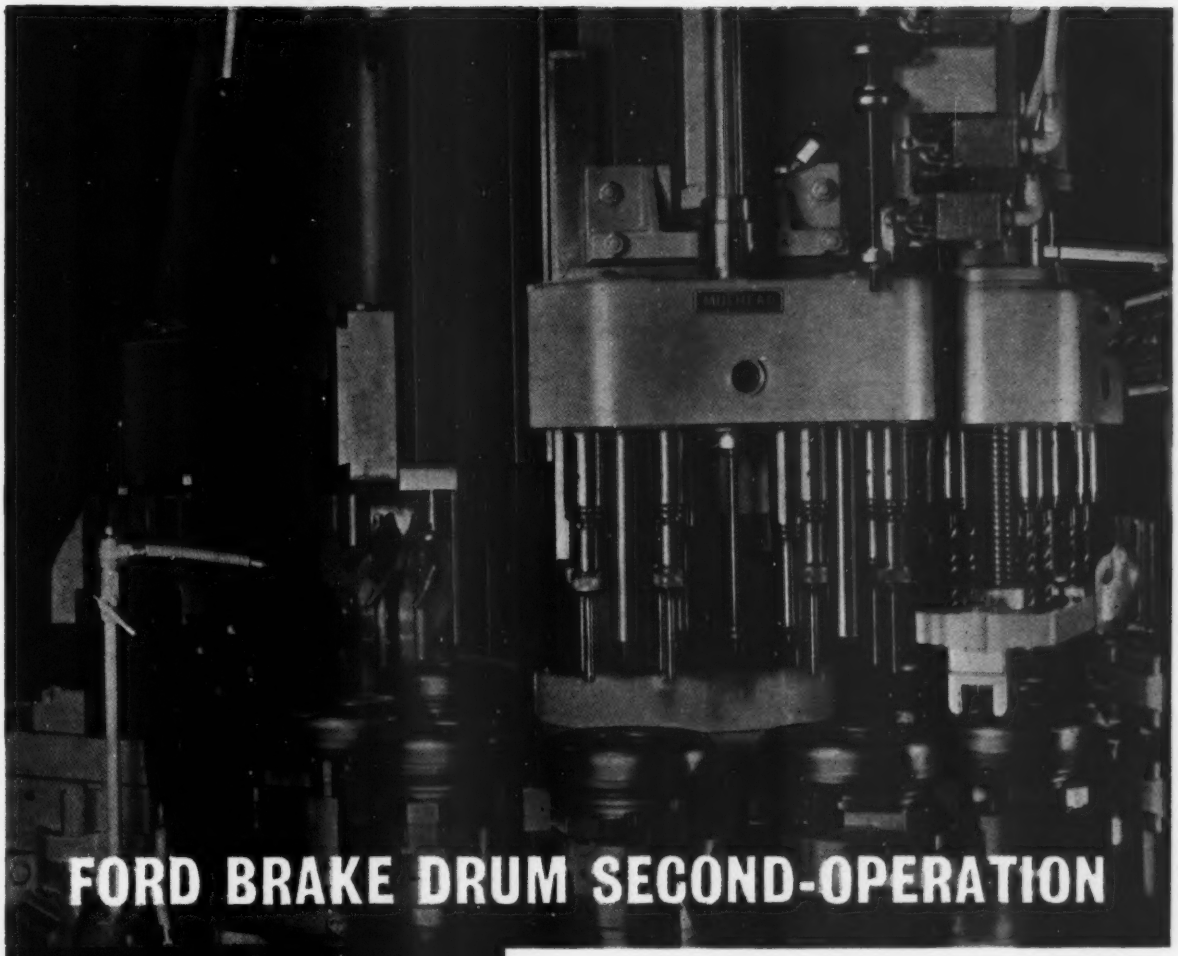
Edgar Allen & Co. Limited
IMPERIAL STEEL WORKS · SHEFFIELD · 9

Post the request form to-day for this Booklet

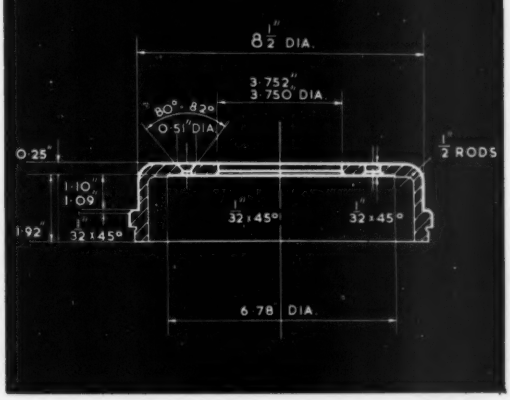
To EDGAR ALLEN & CO. LTD. ETD61/PE
SHEFFIELD 9

Please post data on the Stag Allenite tools to:

Name .....
Position .....
Firm.....
Address .....



FORD BRAKE DRUM SECOND-OPERATION



MACHINED IN 40 SECONDS

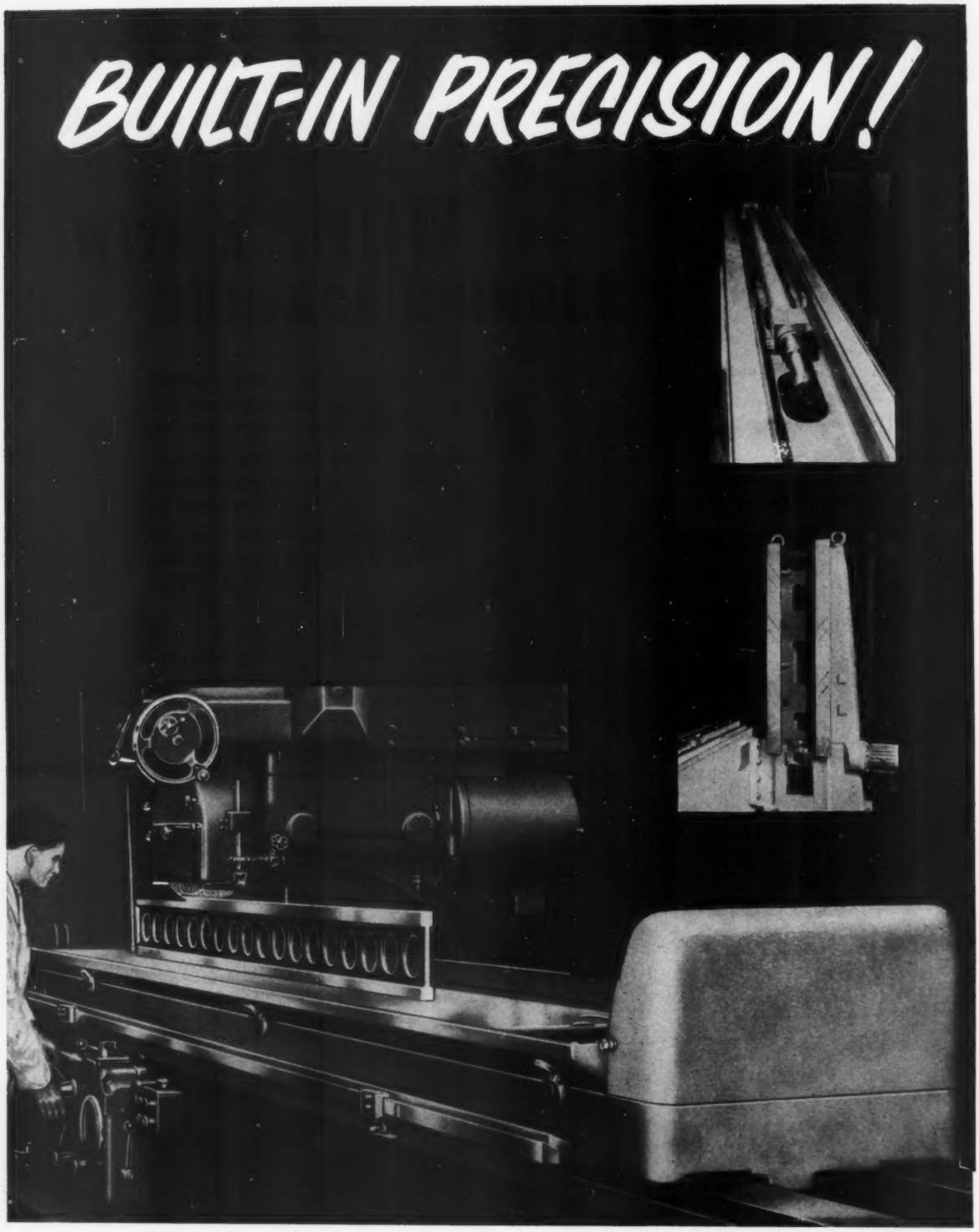
The use of special Mulhead multi-drill heads on the Ryder Verticalauto enables drilling, reaming, countersinking and back-chamfering operations to be performed in addition to standard boring and facing work.

The second operation on this Ford Brake Drum is completed at very high output rates on this 12-spindle No. 10 Ryder Verticalauto.

Ryder ***VERTICALAUTO***

Thos. Ryder & Son, Limited, Turner Bridge Works, Bolton, England
Makers also of single spindle Rydermatics and Piston Ring Lathes

BUILT-IN PRECISION!



Photograph by courtesy of Messrs. J. Chesterman & Co. Ltd., Sheffield.

SNOW & CO. LTD *Machine Tool Makers*

STANLEY STREET, SHEFFIELD, 3. Telephone: 22272

also at LONDON: 58 Victoria Street, S.W.1. Telephone: Victoria 2106

BIRMINGHAM: Daimler House, Paradise Street. Telephone: Midland 4920.

Tungsten Carbide GUN REAMERS

BTG

BIRMINGHAM TOOL & GAUGE CO. LTD.

SOHO HILL
HANDSWORTH
BIRMINGHAM 19

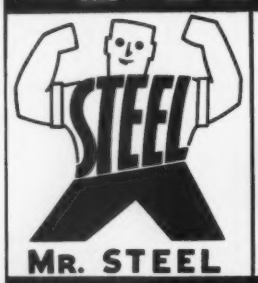
and 26 HOLBORN VIADUCT, LONDON E.C.1

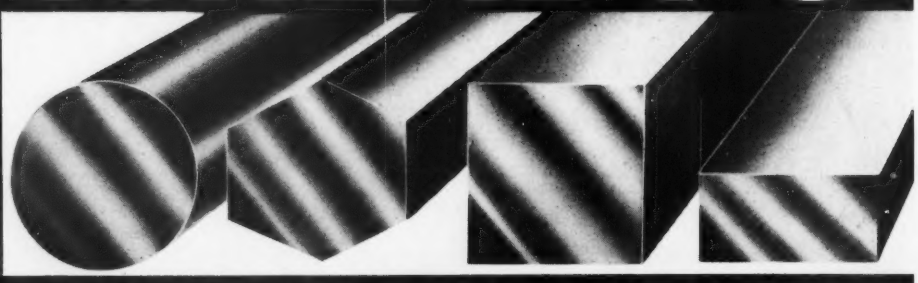
Send for illustrated price list showing details of standard sizes available

FOR HIGH SPEED MACHINING OF HIGH ALLOY & STAINLESS STEELS

Member of the DENBRO Group of Companies

MACREADY'S





BRIGHT STEEL

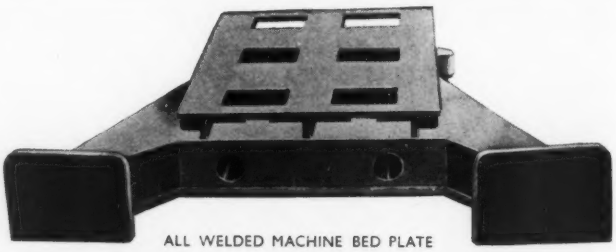
The Macready service is now well-known to users of Bright Steel.
It is the result of excellent warehouse facilities, using our own fleet of lorries for deliveries and an efficient staff to deal with your orders and enquiries.

MACREADY'S METAL COMPANY LTD.

USASPEAD CORNER, PENTONVILLE ROAD, LONDON, N.1

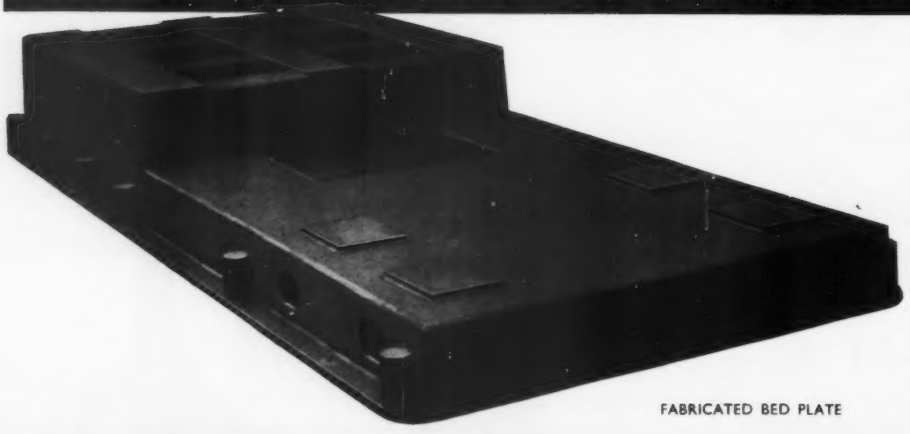
Telephone: TERminus 7060 (30 lines) · Telegrams: Usaspead, London, Telex · Telex No. 22788

This is an example of All-Welded Machine Bed Plates manufactured by this Company. The photographs show how well the complications of modern machine practice can be overcome by this modern method, resulting in great economies.



ALL WELDED MACHINE BED PLATE

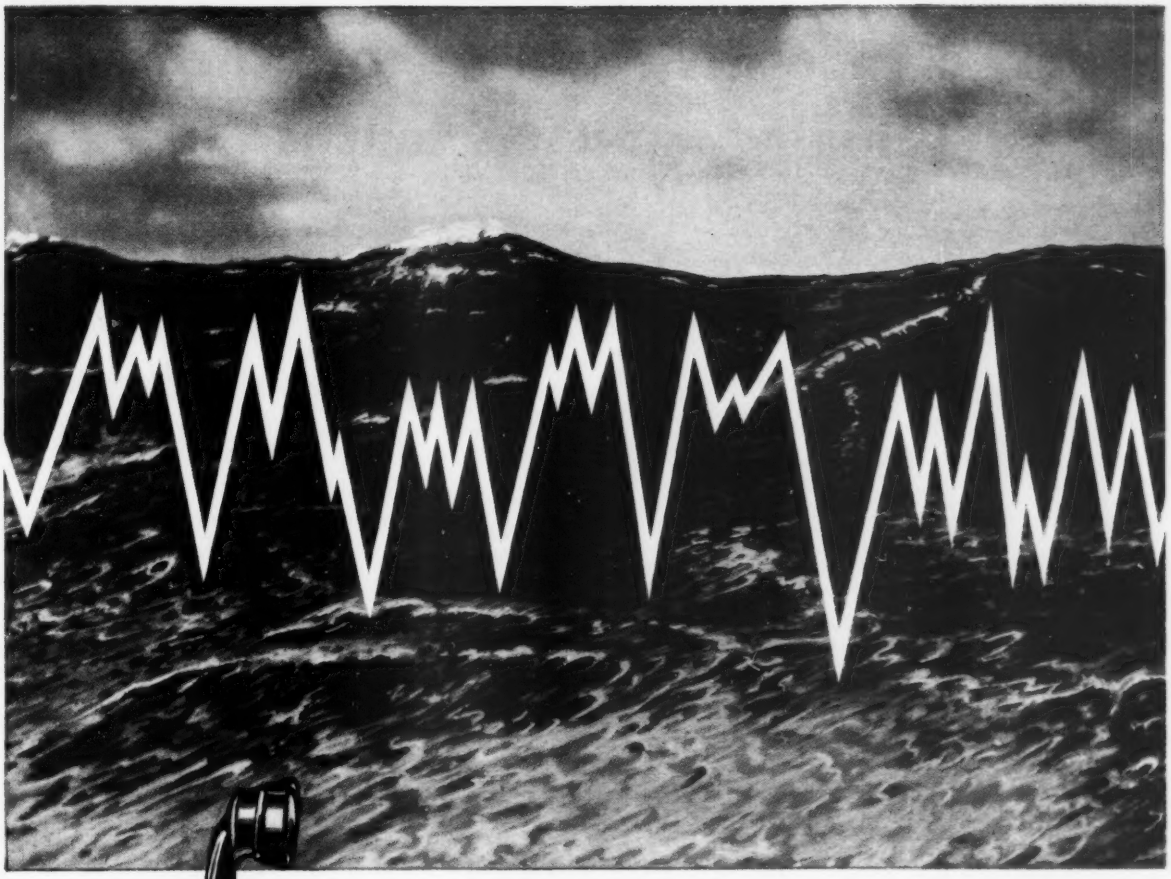
BOLTON RAILWAY WAGON & IRONWORKS CO. LTD.



FABRICATED BED PLATE

We can profile cut any shape in mild steel from ¼" to 6" in thickness. Our products are clean cut and necessitate the minimum of machining and finishing. They make for large economies in reducing the number of operations. Send your enquiries to :-

460 MANCHESTER RD. BOLTON Phone BOLTON 4020 (3 LINES) TELEGRAMS 'WAGON' BOLTON



Telecommunications

Two recent major steps in the improvement of world telecommunications have been the laying of the first Trans-Atlantic and the California—Hawaii submarine telephone cables.

When laying cable either on a flat sea bed or over underwater mountain ranges, the exact control of paying out speed and tension in the cable is of paramount importance. 'VSG' variable delivery oil hydraulic pumps are used to act as brakes on the cable, which is drawn out of the ship by its own weight. This enables a very smooth and regulated control to be maintained or instantly varied to suit ship speed, paying out speed and tension in the cable.

It is just another of the highly varied applications of 'VSG' variable delivery pumps and transmission gears which have now been serving modern industry for over fifty years.

'VSG'

Regd Trade Mark

SERVING MODERN INDUSTRY

VICKERS ARMSTRONGS (ENGINEERS) LTD VICKERS HOUSE BROADWAY LONDON SW1

For competitive plunge or through-feed grinding, and to tenths

Wickman Scrivener

This machine offers accuracy of grinding, quality of finish, and economy of production under the most exacting conditions. With a grinding capacity up to $\frac{5}{8}$" diameter at maximum production rates and 1" for batch work, the No. '0' machine caters for most classes of small work. Many standard features normally regarded as extras contribute to operating efficiency and together with a patented controlled-cycle system for plunge grinding this machine is today's best proposition in small centreless grinders.

If you have a centreless grinding problem — share it with us !

-centreless Grinding Machine

Some standard features.

Maximum opening, new wheels, hand-operated machine	1⅛"
Maximum opening, new wheels, controlled-cycle machine	1⅛"
Grinding wheel size, diameter x width	12" x 3"
Control wheel size, diameter x width	7" x 3"

WICKMAN LIMITED

FACTORED MACHINE TOOL DIVISION, FLETCHAMSTEAD HIGHWAY, COVENTRY

Telephone: Coventry 74321

540 F20/80

The Production Engineer

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. 39 NO. 4 APRIL 1960

ENGINEERING PRODUCTION RESEARCH

by Professor N. A. DUDLEY,
Ph.D., B.Sc., M.I.Prod.E.

This Paper is based on the Inaugural Lecture given by Professor Dudley in The University of Birmingham, on 17th November, 1959, to mark his appointment to the Lucas Chair of Engineering Production. Professor Dudley has been Head of the Department of Engineering Production since 1st March, 1956.

ENGINEERING Production is concerned with the planning, organisation and control of manufacturing industry. Engineering Production research is directed to the discovery and understanding of the nature, characteristics and interaction of the agents of production, and of the scientific principles upon which the planning, co-ordination and control of industrial production are or should be based. The scope of this research will be indicated by reference to the investigations undertaken by the Department of Engineering Production in the University of Birmingham during the past few years.

machine tools

The basic instrument of metalworking industry is the machine tool, which began life as an aid or extension to the skill and effort of the craftsman. Although the machine in a form requiring skilled operation has a key place, even in modern industry, by reason of its versatility, the controls of the production model have been progressively mechanised. This trend — stimulated by the increasing cost of labour and by the demand for more output — together with the development of computer controls and of self-correcting feedback mechanisms, has helped to make the completely automatic factory technically possible, if not, as yet, economically justifiable.

There has been little fundamental research on the design of machine tools, which have been modified over the years in the light of experience and to meet the needs of new materials to be machined or formed and available as cutting or forming agents. Some research has been undertaken to determine the characteristics of machine tool processes — their capacity, in terms of rate of metal removal, surface finish and consistency of performance; their cost in terms of power consumption, tool life, setting time and maintenance. Such information is essential to efficient and economic production planning.

Fig. 1. Model of broaching dynamometer.

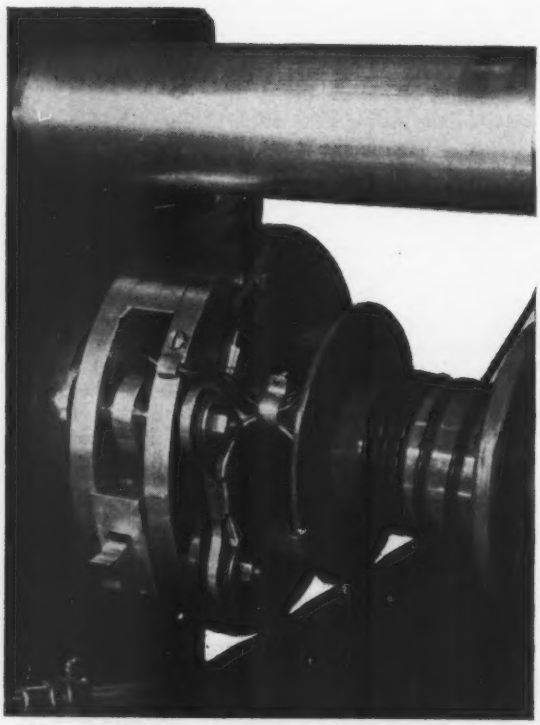


Fig. 2. Milling cutter dynamometer.

Current work at Birmingham on broaching, milling and grinding may be cited as examples of research of this kind.

broaching dynamometer

Broaching is being increasingly used in mass production, principally because of the exceedingly high rate of production of broaching machines, yet little is known of the true nature of the cutting action — particularly on internal broaching — and of the influence of broach design on performance and production cost.

Fig. 1 shows a Perspex model of a broaching dynamometer — to be incorporated in a broach — which will enable not only the vertical forces but also the horizontal forces acting on two opposing teeth of the broach to be studied under various operating conditions. The model is shown in a test rig in which the strain gauge calibration is checked electronically and mechanically (Read 1959).

milling dynamometer

Fig. 2 shows an unique milling cutter dynamometer by means of which the radial and tangential forces acting on a cutter tooth may be recorded throughout the formation of a single chip (Ever *et al.* 1959).

In a comparative pilot study of downcut and upcut milling it has been shown that, although during an initial run-in period upcut milling requires less power and produces a superior surface finish, downcut milling will generally be more economical, since differences in performance after the brief running-in period are insignificant and since downcut milling is associated with a longer tool life.

Hitherto, milling dynamometers have been incorporated in the work holding fixture as in the case of the following study on grinding.

precision grinding research

Grinding is the only method of cutting extremely hard materials and has the added advantage of producing smooth finishes to accurate dimensions in a short period of time. However, the cutting action in grinding is extremely complex and this complexity appears to have discouraged research on this process.

The size and shape of the grinding wheel, the kind of abrasive, the grain size of abrasive particles, the grade or strength of the bond, the structure of the grain and the type of bond material are all factors in the selection of grinding wheels, though the grading of the wheels themselves in industry is, as yet, extremely uncertain.

Other factors to be investigated in the grinding of a particular material are wheel speed, table speed, vibration, depth of cut, wheel wear, temperature, surface finish and power consumption.

Fig. 3 shows a Churchill horizontal grinding machine — a standard production model but for a special vertical fine-feed mechanism — on which is

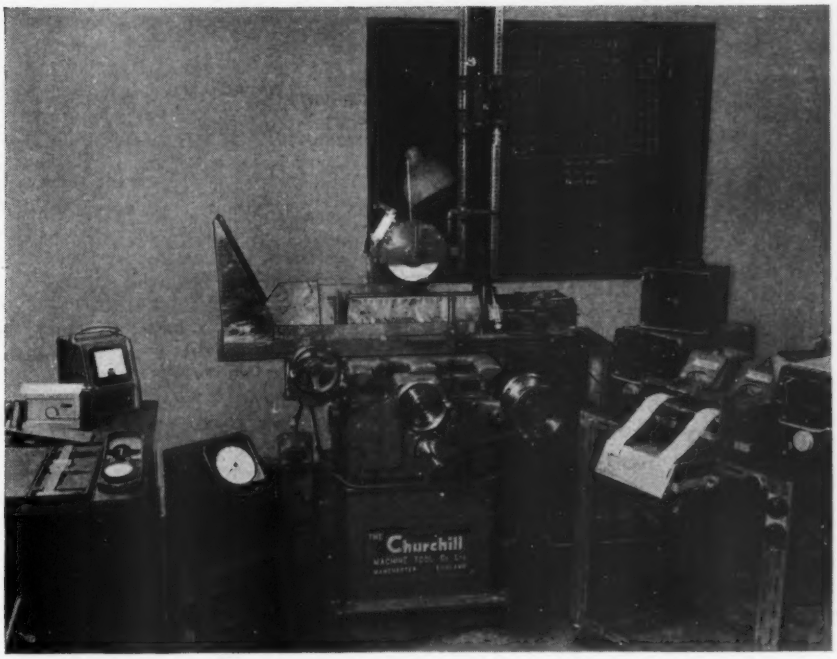


Fig. 3. Equipment for grinding research project.

mounted a special dynamometer and other instruments for recording the several variables under examination (Grisbrook. 1959). In the foreground are rectilinear recorders which trace the horizontal and vertical components of the grinding force. Behind the machine is equipment for recording actual work speed and wheel speed throughout the machining process, the dials of this equipment being situated in the field of a Kodak Cine Special camera.

Fig. 4 shows the horizontal and vertical components of the grinding force throughout one working stroke, together with the falling wheelspeed and resultant chip thickness. Perhaps the most important finding to date, shown in Fig. 5, is that — with reference to the rate of metal removal — there is a critical point at which the nature of the grinding action changes abruptly. At the high rates of metal removal the action is one of cutting, at low rates predominantly one of rubbing.

Fig. 6 shows the deterioration in the quality of the surface finish associated with wear of the grinding wheel (Hollier 1959).

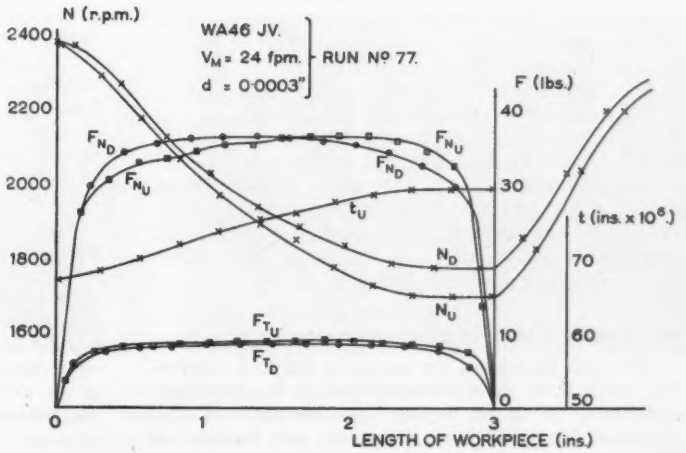


Fig. 4. Normal and tangential forces (F_N, F_T) wheel speed (N) and chip thickness (t) for downcut (D) and upcut (U) grinding.

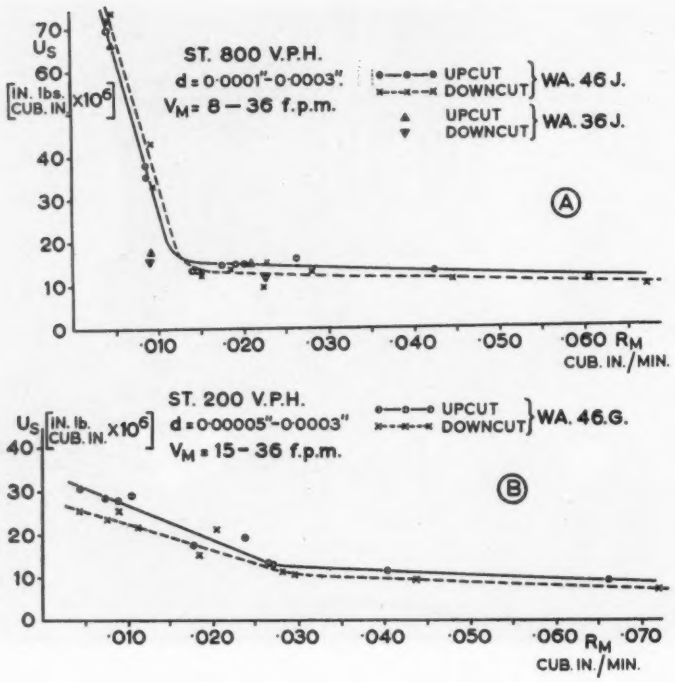


Fig. 5. Specific energy — rate of metal removal. Upcut and downcut grinding.

surface finish measurement

The measurement of surface finish is normally accomplished by the use of instruments which indicate the amount of rise and fall of a stylus as it is drawn across the surface of the work. Fig. 7 shows specimens of milled, turned and ground surfaces specially prepared as standards against which to compare measurements obtained with such instruments currently in use in industry.

Fig. 8 gives readings obtained from mechanically operated and from manually operated instruments and also — in the case of the latter — with the aid of a special motor-tracking fixture. This study revealed an extraordinary range of performance of the instruments and the considerable effect of human skill and judgment (Jones *et al.* 1959).

The instruments examined included those used by the instrument manufacturers themselves and the specially tuned instrument belonging to the Department of Engineering Production, which gave a spread of readings of 10%. One instrument when operated mechanically gave spread of readings of 18% and of only 15% when manually operated. Another instrument gave a spread of as much as 60% when operated by an inexperienced worker.

the human factor in machine control

Most machine tools are manually fed and controlled, and their productive efficiency is, therefore, influenced in some degree by the skill of the operator. Much work on the design and location of manual controls — handwheels, setting dials and levers — has been undertaken in the United Kingdom and abroad. So far as the United Kingdom is concerned, the research findings have had little impact on industrial practice. It would seem that, in some instances, this is because research has not been concentrated on those factors with which machine designers and production engineers are principally interested.

For example, many studies have been made to determine the time required to set dials by the use of handwheels of various sizes. In the case of milling and grinding machines, however, of much greater importance than the time involved in setting the dials, is the accuracy with which dials can be set.

A recent study (Corlett 1959a) has revealed the influence of dial size, thickness of dial graduation lines, handwheel size and frictional torque on the accuracy of setting. Fig. 9 shows how the accuracy of the setting — as these and other conditions were varied — was determined directly with the aid of an optical dividing head.

Fig. 10 shows the effect, for skilled workers, of varying dial diameter and line thickness. Dial diameter is seen to have an important influence on accuracy of setting and line thickness to be unimportant. The diagrams in Fig. 11 show that handwheel diameter and frictional torque are both unimportant from the point of view of accuracy, so far as skilled workers are concerned. The greater the friction, however, the longer is the time required to make the setting.

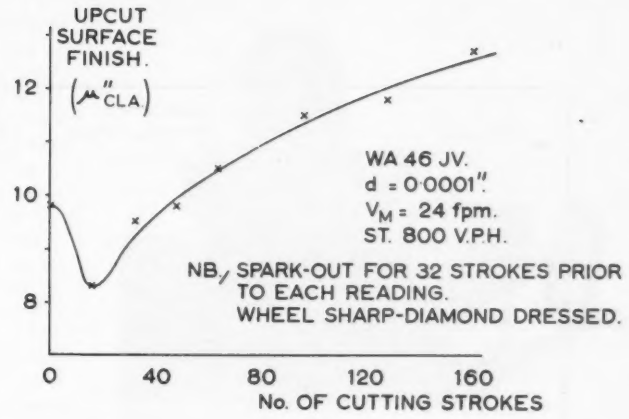
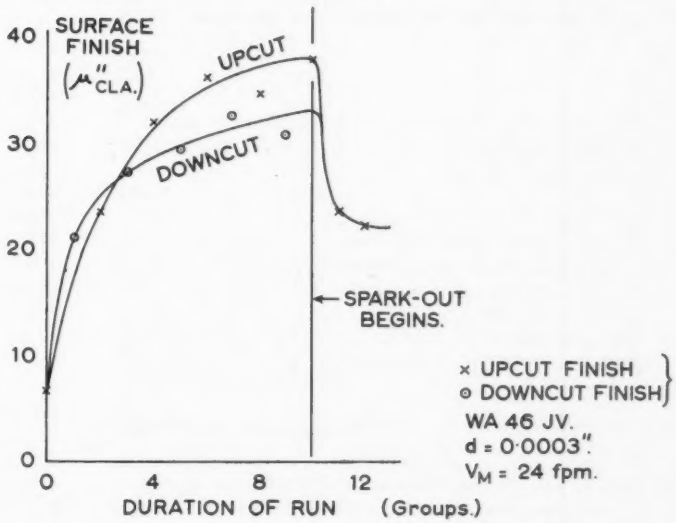


Fig. 6. Effect of wear of grinding wheel on surface finish.



repetitive manual operations

The characteristics of worker performance, for example, the nature of skill and the determinants of operation time, are as yet, only imperfectly understood.

It appears that—so far as the simple but highly repetitive tasks, typical of mass production, are concerned — the method of performing an operation generally has a greater influence on the time to perform it than do individual differences between workers. It appears that the introduction of an operation element necessitating the conscious attention of the worker, though increasing the work load, frequently results in a reduction in the time taken to perform the operation.

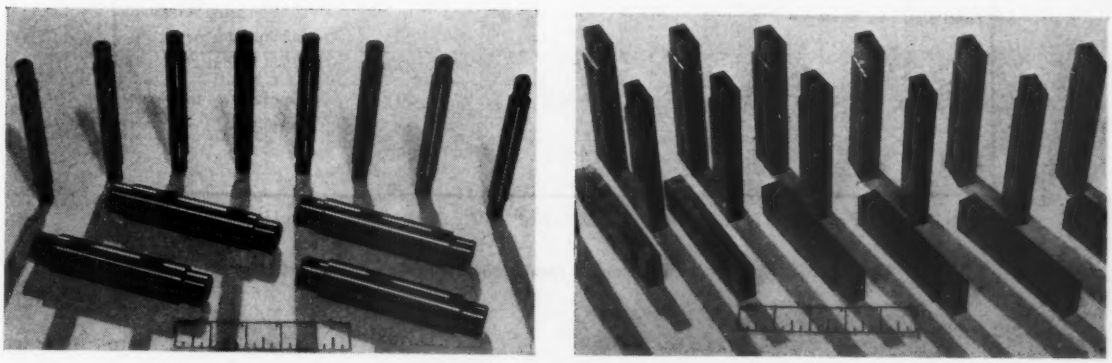


Fig. 7. (left) Cylindrically ground and carbide turned reference specimens; (right) Surface ground and milled reference specimens.

Instrument	*Method of Use*	*Displacement of Operating Mean (Estimate)*	*Spread of Readings (Estimate)*	*Remarks*
A	MO	0%	10%	Mean of samples of 9 readings
	MO	0%	18%	—
	MO	0%	12%	—
	MO	—2%	14%	—
B	MO	—3%	11%	—
C	MO	—12%	17%	—
D	MO	+10%	21%	Readings below 10 micro-inches C.L.A. not included
	MA	0%	37%	—
	MO	—5%	20%	Readings below 10 micro-inches C.L.A. not included
E	MO	—15%	18%	Readings below 10 micro-inches C.L.A. not included
	MA	—14%	15%	Readings below 10 micro-inches C.L.A. not included
F	P	—7%	19%	Readings below 15 micro - inches not included
	MA	—22%	32%	Readings below 15 micro - inches not included
G	MO	+30%	25%	Readings below 15 micro - inches not included
H	P	—	—	Operating mean of instrument appears to be skew with respect to operating mean of instrument A.
	P	—	—	
	P	—	—	
I	P	0%	27%	—
	MA	+10%	60%	Operator not experienced
	P	+8%	26%	—

MO — *Motor Tracking* MA — *Manual Tracking* P — *Simulated Motor Tracking Using Fixture*

Fig. 8. Surface roughness assessment : results obtained from instruments tested.

It has been established, contrary to widely-held belief, that experienced workers, who are free to work at their own pace on repetitive manual tasks, acquire a working pace which they maintain throughout the work period, irrespective of the magnitude and distribution of interruptions resulting from delays and necessary ancillary activities (Dudley 1958a).

It has also been shown that it is possible to assess the degree of skill of a worker by analysing the distribution of operation cycle and element times.

The diagrams in Fig. 12 record all of the times taken by an experienced worker and a trainee to perform a simple assembly operation during a whole working day. A trainee, in this context, means one who has been taught a standard method of performing the operation but has not yet acquired the speed of the experienced worker. It is of interest to note that the trainee occasionally does the job in the best time of the experienced worker and on no occasion exceeds the longest time of the experienced worker. From a large number of studies it has been found that positively skewed distributions are indicative of skilled performance (Dudley 1955a).

Substantial evidence of the absence of any trend in the time taken by trained and experienced unpaced workers to perform repetitive manual tasks throughout the work period has invalidated interpretations of the so-called typical saddleback output curve, which is, in fact, to be explained not in terms of pace but simply in terms of the distribution of productive and non-productive time.

paced performance

In much large-scale production, however, operators on highly repetitive work are not free to work at their own natural pace, but are given a certain maximum period of time within which to complete their specific tasks; they have a work station on a conveyor belt, or are required to keep pace with a machine.

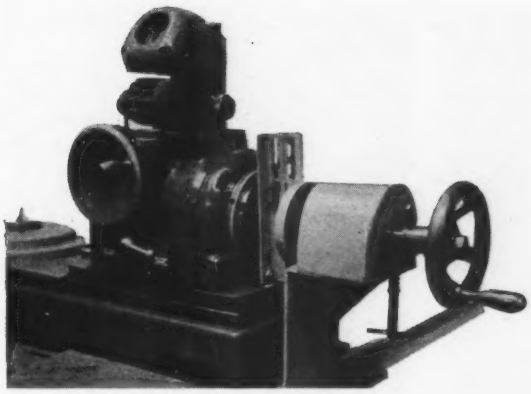


Fig. 9. Equipment used in study of dials and handwheels.

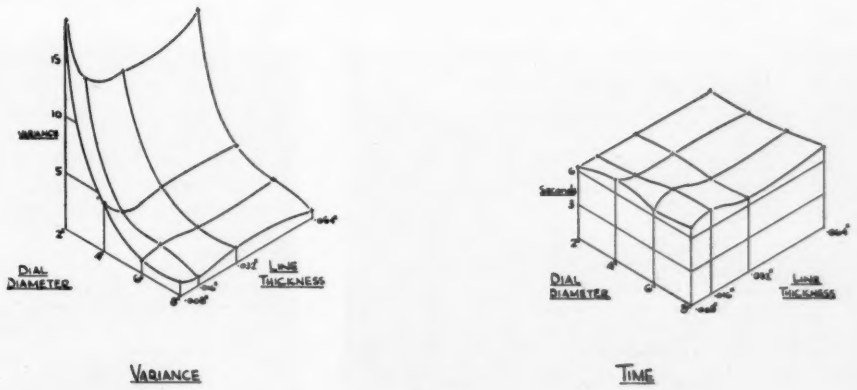
It has been observed that the performance of such workers, by contrast with that of unpaced workers, is less consistent and potentially less efficient (Dudley 1955b).

What has yet to be determined is the optimum speed, or speeds, at which processes should run to ensure maximum efficiency of operation, or, preferably, some means of reconciling the demands of the process and the natural characteristics of workers' performance. What have also to be investigated are the effects of shift working and abnormal working conditions on work pace.

laboratory experiments

Field studies are indispensable in this type of investigation but their understanding necessitates more refined and analytical laboratory experiment. Research in this context has involved measuring the

Fig. 10.



THE EFFECTS OF VARIATION OF DIAL DIAMETER AND LINE THICKNESS

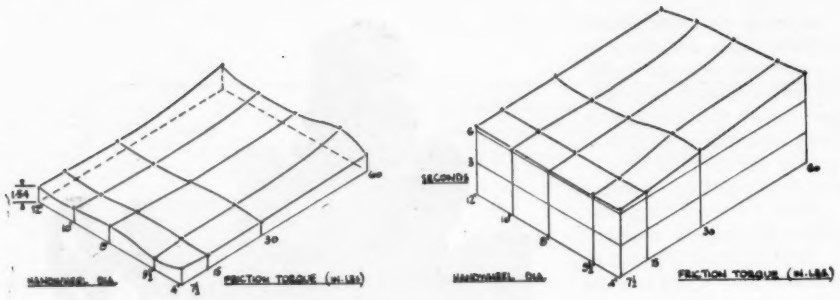


Fig. 11.

VARIANCE

TIME

THE EFFECTS OF VARIATION OF HANDWHEEL DIA. AND FRICTIONAL TORQUE ON SPINDLE

time to perform very small elements of operator movement.

The instrument shown in Fig. 13, a sequential electronic timer and recorder (SETAR), the prototype of which was designed by Dr. Norman Welford, formerly of Cambridge, times the interval between signals fed into its eight channels to 1/100ths of a second, and codes and records them on punched tape which is then translated by teleprinter in the normal way. Supplementary recording gear, including a 12 pen kymograph, gives a graphical record which is used to help to interpret SETAR's readings. This equipment is housed in a sound-proof cabinet to prevent subjects from being paced by the recording unit.

Several experimental operations have been designed for use in researches on the nature of skill, the processes of learning, the effect on pacing on operation time, and the effect of increasing the perceptual load.

One of the long-established principles of worker motion economy is that movements which are simultaneous, symmetrical and in opposite directions are the least fatiguing. The primary purpose of the experiment shown in Fig. 14 — which can involve either or both hands — is to determine the extent to which movements can, in fact, be instantaneously symmetrical. The apparatus is in two halves which may be progressively moved further apart (Smedley 1957).

Fig. 15 shows an operation which comprises simply the grasping of a small component and its insertion in a given location. The objects to be grasped are presented to the subject on a motor-driven conveyor, the speed of which can be varied. The length of the conveyor, within which the object has to be grasped, can similarly be varied, and the subject may also be presented with alternative location points (Keay 1959).

In Fig. 16, steel balls of different colours are presented in random order to the subject of the experiment. These balls have likewise to be grasped and positioned in the location indicated similarly by colour. Alternatively, the four locations, the positions of which may be changed at will, may be replaced by a single location. The shape of the location receiving the balls is yet another variable.

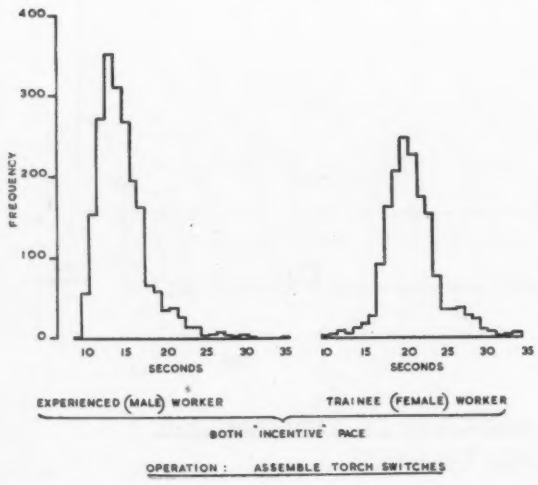


Fig. 12. Frequency distribution of operation times.

In this particular series of experiments interest is centred on those factors which affect the time to perform the operation.

One of the experimental difficulties is that of defining and registering the end points of the small elements of motion, and, in this, the use of films and of photo-electric cell beams is of limited value.

The most successful technique developed so far is that of passing a small electric current through the subject's body and defining the point of contact or release of the hand with the work or tool as the end-point of the particular element of movement.

Such investigations contribute to the improvement of the design of equipment and of products, and to the establishment of more accurate time standards for purposes of production planning.

An interesting finding is that the ratio of the constituent motion element times of an operation, though consistent for unpaced workers working at a constant pace, changes radically with voluntary changes in pace and with the acquisition of skill.

As an example, Fig. 17 shows the varying rates of decrease of motion element times as the overall time of an operation is reduced.

A practical consequence of this finding is that the time required to train workers on repetitive tasks in industry has been considerably reduced, since training can now be concentrated on those elements of the task that are likely to respond most to supervised practice.

In addition to the examples given, which were concerned with simple operations of the assembly type involving varying degrees of manual dexterity and decision-making, studies have been made of operations in which the perceptual load predominates, for example, operations of inspection and sorting (Seymour and Crossman 1957).

Although, for reasons of economy, large numbers of workers are still engaged on highly repetitive tasks, there is a considerable trend towards automatic production, which in engineering manufacture means

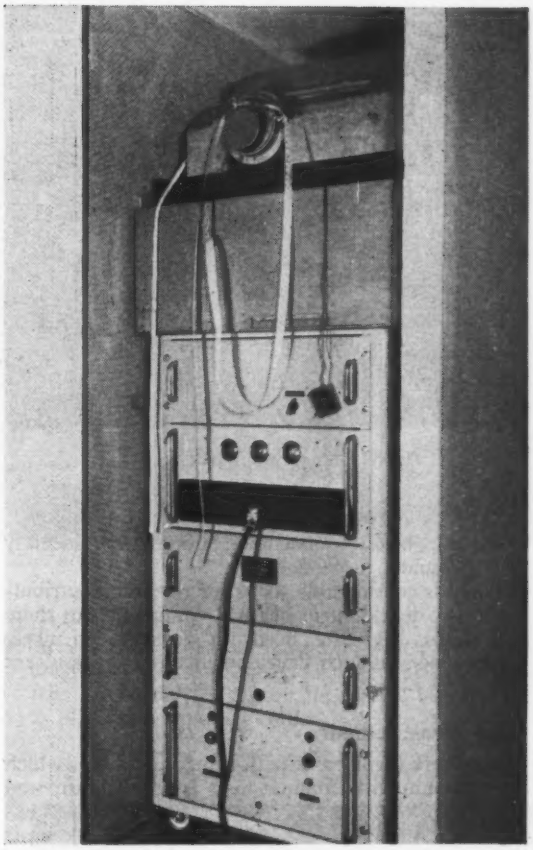


Fig. 13. Sequential electronic timer and recorder (SETAR).

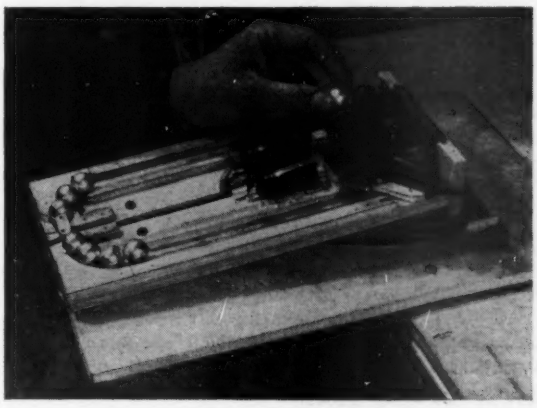


Fig. 14. Study of simultaneous motions.

Fig. 15. Study of paced performance.

Fig. 16. Study of perceptual load.

automatic transfer machines, automatic assembly and automatic inspection.

There is considerable scope for research contributing to the development of such equipment, but there is perhaps a greater need for research on likely consequences of such developments and on resultant problems.

work measurement

The work involved in performing operations which are predominantly manual tasks is usually expressed in terms of the time taken to perform the operations at some agreed level of performance. Such time standards have to be established for purposes of production planning, cost estimating and accounting and — where payment-by-results schemes operate — as a basis for worker remuneration. Much research has been done in recent years to establish work measurement techniques on a scientific basis (e.g., Edmondson 1957).

In the near-automatic factory, however, orthodox techniques will no longer be applicable; physical work gives place to operations of the dial watching type requiring a high degree of vigilance and scrutiny.

Research has led to the development of a means of analysis of the perceptual load imposed by such work in terms of the senses involved — kinaesthetic, touch, hearing, vision — and the mental processes of plan, initiate, control and check. An evaluation of this perceptual load is then made by application of information theory, that is, in terms of the number of bits of information handled (Crossman 1956).

automation and human skill

It is commonly assumed that the design and use of completely automatic manufacturing equipment is limited only by considerations of demand for the product and that, given unlimited demand, automatic production is the most economic production.

This is not necessarily true, for there are certain operations which can, at present, be performed not only more economically but sometimes more quickly by the use of manually than by the use of automatically controlled machines.

An example of these is the drilling of small diameter holes, particularly where the initial contact or break-through imposes a side thrust on the tool, or where the workpiece lacks homogeneity by reason of, for example, hard spots or blow-holes.

Numerous attempts to mechanise this operation have been abandoned because of excessive drill breakage — as much as six times that associated with manual feed — and resultant stoppages of an entire production flow-line.

It would appear that the human feed-back and control mechanism is not only more refined but is more efficient than that of the mechanical control.

The feed mechanism of automatic drilling heads has been made to respond to changes in thrust and to changes in torque with only a moderate degree of success, and it would appear advantageous to simulate the essential features of the human feed-back system in the mechanical control unit.

Machine tool designers will be unable to do this, however, until the signals from which the human

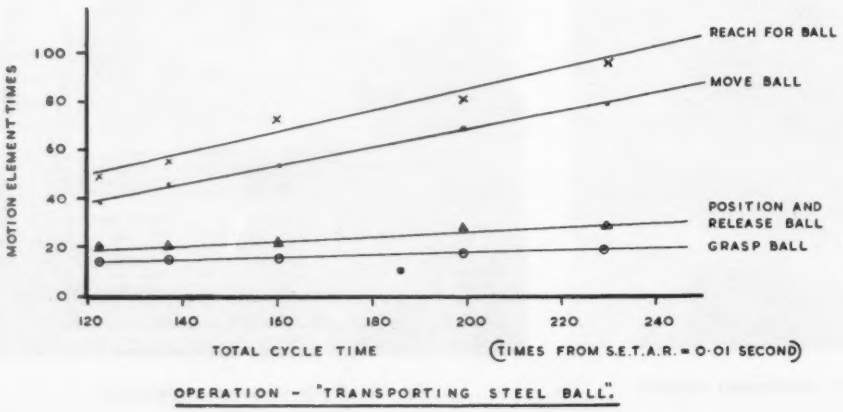


Fig. 17. Motion pattern variability.

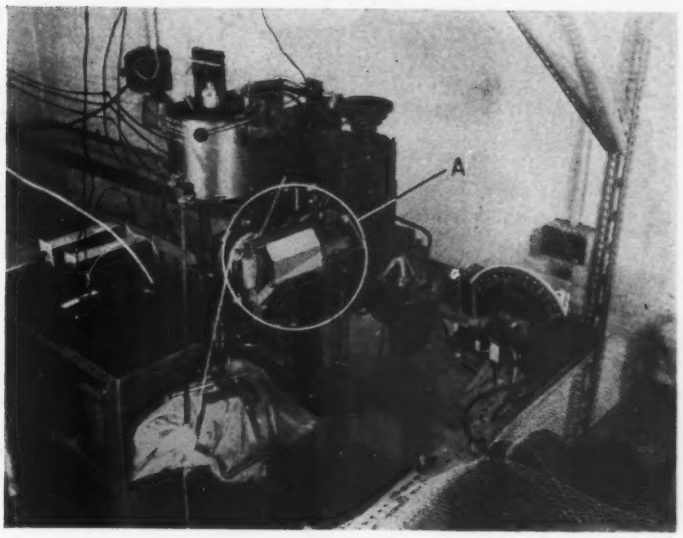


Fig. 18. Equipment for study of nature of operator's skill in drilling.

operator derives information, and on which he acts, have been identified and dimensioned.

human factor in machine control

Research is currently being undertaken to determine the fundamental nature of the machine operator's skill — the nature, timing and effect of the response he makes to changes in the job (Corlett 1959b).

Fig. 18 shows a sensitive drilling machine equipped with a dynamometer and other instruments in such a way that thrust and torque can be recorded for the whole duration of the operation, or any part of it — the torque, thrust and feed signals being produced by means of strain gauge bridges. In addition, changes in drill vibration and in noise frequency and level, are also being recorded, together with changes in the rate of feed and spindle speed.

The significance of visual signals is determined by blindfolding the subject, as shown in Fig. 19, while the significance of drilling noise as a guide to control is determined by superimposing noise of greater intensity through earphones.

An auxiliary unit has been developed to measure the sensitivity of operators to changes in drilling pressure (Lee 1959).

electromyography

Since the purpose of this research is to determine the signals to which the operator responds during the drilling process, it is necessary to study the nature and timing of the physiological responses. Use is being made of electro-myographical records of the action of the deltoid muscles, that is, those muscles which are used when the shoulder joint is rotated during the operation of the lever of the machine.

By relating muscular action, and nerve impulses preceding action, to changes in drill thrust, torque, noise and vibration, it is sought to identify the critical sources of information on which the operator acts and which must be made to regulate automatic feed mechanisms if automatic control is to be made as efficient as manual control.

Fig. 19. Determining significance of visual signals in drilling.

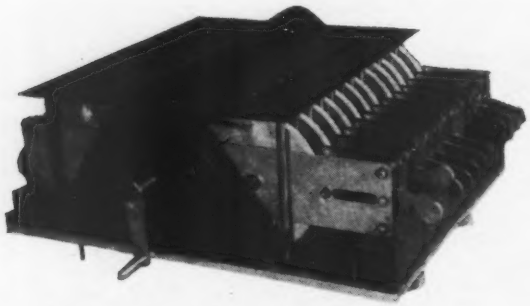


Fig. 20. Machine interference model (Hartshorne).

mechanical control unit

To assist in the formulation and testing of any hypotheses arising from this investigation, and to act as a bench mark, a mechanical feed control unit has been built (Beavor 1959). The unit, shown at A in Fig. 18, can be operated electronically at any chosen level of signal from the drill.

complexity of production

Thus, attention is being directed to an understanding of industrial skills, to the characteristics of machine tool and other processes and particularly to man-machine control systems.

But the attainment of technical perfection of the tools of production and of their competent operation is but one stage in efficient and economic engineering production.

If the output of individual machines and processes and of workers were infinitely adjustable, and if the desired volume and quality of output at any moment were those which could be produced at minimum cost per unit, production planning would present no serious problem.

In fact, because of the different output rates of production processes, there is a tendency for work to pile up between certain machines and for certain other machines to be kept waiting. Superimposed on the inherent differences in capacity and quality of output of new machines are the effects of age and use and misuse. Machines have to be serviced and they have to be maintained. Their capital running cost varies, as does the cost of raw materials and of labour and the demand for the finished products.

operational research

Preparation of the simplest production plan involves consideration of many variables, and research is being undertaken so that — in the determining of optimum production strategy — scientific evaluation of the situation may supplant trial and error and supplement experience.

In this, the specialised mathematical and statistical techniques of operational research, assisted by computers, are indispensable aids, though it is unlikely that they can ever encompass all the factors involved in a complete production programme, and doubtful whether they should be expected to do more than present, as measured alternatives, guides for decision making.

Most of the work undertaken, so far, has been concerned with production scheduling, inventory control, and the allocation of productive resources (e.g., Page 1957).

Some contribution has been made to the forecasting of the duration and distribution of non-productive time when an operative has to tend a number of machines with irregularly occurring stoppages (Benson 1957).

The most comprehensive approach to such "machine interference" problems would be by way of mathematics — as a special case in the theory of queues, which is a branch of the theory of probability. However, although there are mathematical methods for solving such problems, even in some fairly simple situations the resultant mathematical problems are complex. For example, the situation in which machines are subject to two kinds of fault leads to a set of linear difference equations, but a general solution of these and of similar sets of equations has not been found, and the equations have to be solved numerically. For large sets of equations, this necessitates some mechanical method of solution.

If some mechanism is needed to solve an idealised version of the real problem, this may be less efficient than creating a mechanism which solves the real problem.

Two attempts by students in the Department to build such mechanisms — briefly referred to in an earlier Paper (Dudley 1958b) — are described below.

machine interference models

The machine shown in Fig. 20 simulates the operation of a battery of 10 machines which are represented by a series of carriages, each of which bears two discs in tandem (Hartshorne 1957). The discs — with numbered graduations around their

Fig. 21. Machine interference model (Sagar).

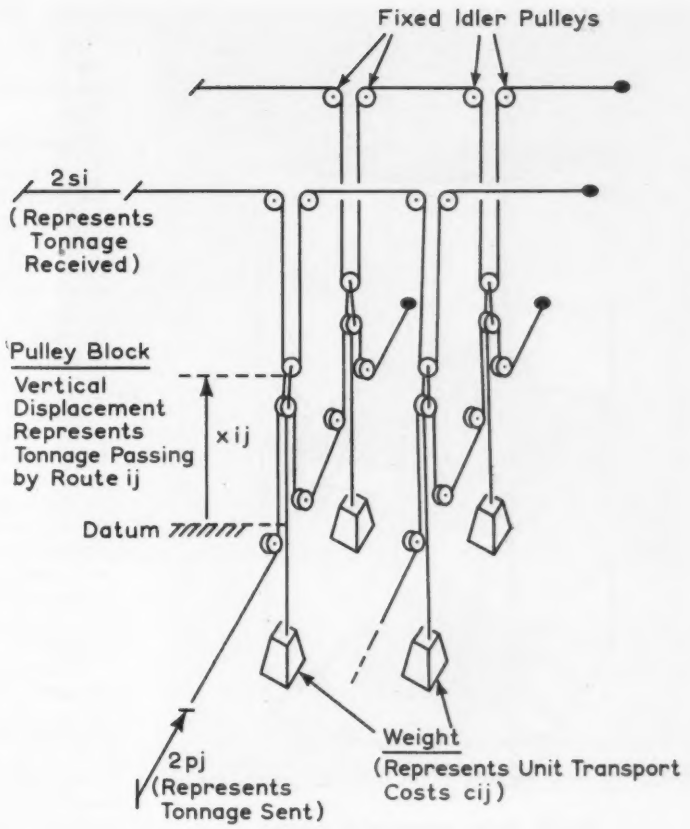


Fig. 22. Principle of linear programming analogue.

peripheries — are set in accordance with productive and non-productive times, sampled from the actual machines.

There are three settings of each slide: forward, centre and rear, indicating that the machine is running, is idle or is being tended. When the discs are in the forward or rear positions they are rotated by the hand crank to indicate the passing of time.

Actual machine running times, machine loading and other non-productive times are likewise sampled and fed into the model shown in Fig. 21, which simulates the operation of a battery of eight machines (Sagar 1958).

Four pairs of rows of keys on each of these modified calculating machines relate to the eight machines. When the machine running or other time has elapsed, an electric bulb lights up to indicate that the machine requires attention.

By this means, it is possible, for example, to determine the effect on machine utilisation of having one, two or more operatives available to attend to the machines as required.

linear programming analogue

Another model — a system of strings, weights and pulleys—has been developed which enables the most economic routes to be selected in the classical transportation type of linear programming problems.

The principle of the analogue is shown diagrammatically in Fig. 22 (Stringer and Haley 1957).

The four pulley blocks represent alternative routes (within a factory, or between factories) by which materials may be conveyed. Suspended from each pulley block is a weight which represents the unit cost of transporting the material by that route.

The pulley blocks are interlaced in the horizontal plane by the strings, the extension of which represents the amount of material to be despatched from (in this case) two supply points, and normal to these, strings the contraction of which represents the amount of material to be received at (in this case) two destinations.

Fig. 23 shows the actual mechanical analogue which has 10 supply points, 10 destinations and, therefore 100 pulley blocks, that is 100 alternative routes. The model is set initially with the pulleys all in the same horizontal plane. When adjustments are made to the lengths of the interconnecting strings in accordance with the supply and demand requirements, there is a resultant vertical displacement of the pulley blocks.

The condition of minimum overall transport cost is represented by the condition of minimum potential

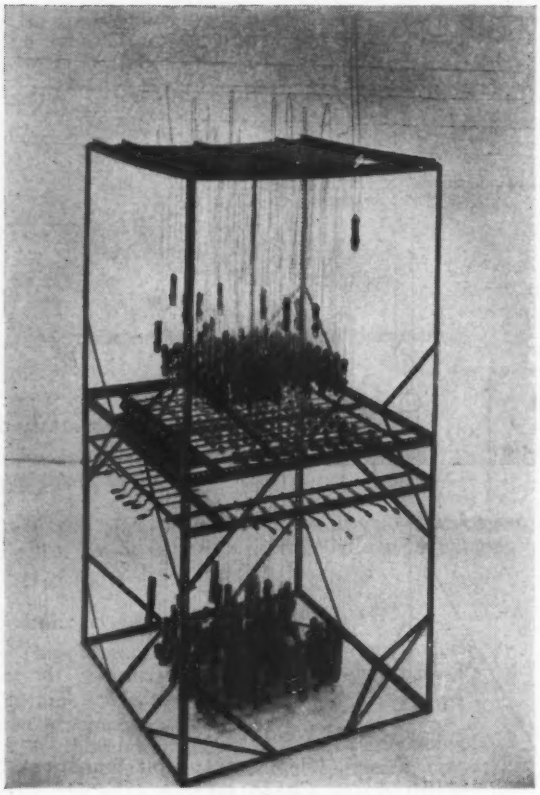


Fig. 23. Linear programming analogue.

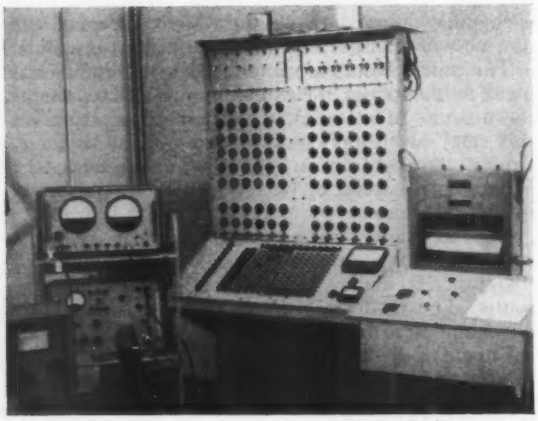


Fig. 24. Analogue computer with production control simulator on the right.

energy. The rising of certain pulley blocks indicates that these are the most economical routes to use; the amount by which the pulley block rises indicates the amount of material to despatch by that particular route.

production control simulator

Work has also begun on production control by analogue computer.

So far, this has involved the design and construction of a production control simulator for use in conjunction with a general purpose analogue computer (Sunde 1959).

The control panel of this unit, shown in Fig. 24, displays a production monitor and a demand monitor, with range adjustment knobs for each, and control knobs for stock limits, production delays and demand.

The rear view of the unit in Fig. 25 shows the production function generator, comprising a motor, gearbox and potentiometer.

The underlying concept of this original feedback control system is that the flow of production units through the factory must be directed so that there will exist a state of equilibrium, at any time, between consumer demand, rate of production and stock level. The next stage is to impose cost constraints on the system.

The value of this approach is that it makes possible dynamic control of production.

production — a single process

But the most challenging, the most complex and potentially the most rewarding research is that which seeks to understand the entire manufacturing unit as a single process — a process in which the attitudes of the participants may be more important than their capacities, and in which technical efficiency may not always be compatible with economic production.

The identification and classification of basic patterns or types of production, to replace the present rather crude analyses, would speed the diagnosis of production inefficiencies, and lead to the more accurate prediction of future trends and anticipation of future developments.

The understanding of the peculiar function of individuals and groups would make it possible to construct what is so urgently needed — a network of productivity indices or performance criteria extending from shop floor to board room, and without which the contributions of the agents of production cannot be effectively co-ordinated and integrated.

When such reliable predictions are possible, and when clearly-defined, interlocking and complementary objectives are established, then, the only outstanding prerequisites of completely automatic self-regulating control of production will have been met.

acknowledgments

The continuous support and active co-operation of many industrial companies, Government departments and research bodies with this and other work of the Department of Engineering Production is

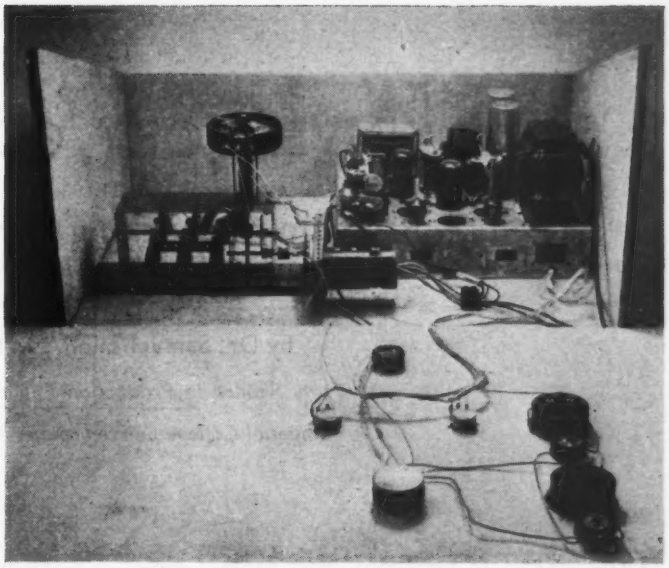


Fig. 25. Rear view of production control simulator with top panel removed, showing production function generator to the left of the chassis.

gratefully acknowledged. Individual recognition will be given in the several Papers and research reports as they are published.

On the occasion of the author's appointment to the Lucas Chair of Engineering Production, however, the Department would like especially to acknowledge its indebtedness to its principal benefactors, the Joseph Lucas Company Limited, whose foresight and generosity have made possible the establishment and development of Britain's first University Department of Engineering Production, and to Dr. T. U. Matthew, M.I.Prod.E., who, as the first Lucas Professor, laid the foundations for much of the work referred to in this Paper.

REFERENCES

BENSON, F. 1957. "Machine Interference; A Mathematical Study of Some Congestion Problems in Industry." Ph.D. (Eng.Prod.) Thesis. University of Birmingham.

CORLETT, E. N. 1959a. "The Accuracy of Setting of Machine Tools by means of Handwheels and Dials." To be presented at Ergonomics Research Society Conference, Cambridge, 1960. 1959b. "Human Factors in Machine Control." Thesis in preparation. Department of Engineering Production.

CROSSMAN, E. R. F. W. 1956. "The Measurement of Perceptual Load in Manual Operations." Ph.D. (Eng.Prod.) Thesis. University of Birmingham.

DUDLEY, N. A. 1955a. "Output Pattern in Repetitive Tasks." Ph.D. (Eng.Prod.) Thesis. University of Birmingham. Appendix D. "Frequency Diagrams of Operation Times;" 1955b. Ibid. Appendix E. "Motion Pattern Variability." 1958a. "Output Pattern in Repetitive Tasks." Institution Production Engineers Journal. Volume 37, Nos. 3, 4, 5 and 6. 1958b. "Operational Research in Engineering Production." Institution Production Engineers Journal. Volume 37, No. 11.

EDMONDSON, F. 1957. "Research Studies in Basic Skilled Movement Times." Final report. Leverhulme Research project, Department of Engineering Production, University of Birmingham.

EVER, Y., SMITH, R. C. and GRISBROOK, H. 1959. "A Milling Cutter Dynamometer." Report awaiting publication. Department of Engineering Production, University of Birmingham.

GRISBROOK, H. 1959. "Precision Grinding" Official Degree Thesis. University of Birmingham.

JONES, P. F. *et al.* 1959. "The Accuracy of Centre-line Average Height Assessment for Typical Production Finishes Using Stylus-operated Electro-mechanical Instruments." Report in preparation. Department of Engineering Production, University of Birmingham.

PAGE, E. 1957. "A Study of Queues in Manufacturing Processes." Ph.D. (Eng.Prod.) Thesis. University of Birmingham.

SEYMOUR, W. D. and CROSSMAN, E. R. F. W. 1957. "The Nature and Acquisition of Industrial Skills." Final report. MRC - DSIR project, Department of Engineering Production, University of Birmingham.

STRINGER, J. and HALEY, K. B. 1957. "The Application of Linear Propramming to a Large-scale Transportation Problem." Proc. First International Conference on O.R., Oxford. English Universities Press.

The following references are to unpublished reports submitted as part requirement for the M.Sc. degree or postgraduate Diploma in Engineering Production, University of Birmingham.

BEAVOR, C. J. 1959. "Machine Controlled Drilling."

HARTSHORNE, J. M. 1957. "Machine Interference."

HOLLIER, R. H. 1959. "Further Research in Precision Surface Grinding."

KEAY, D. R. 1959. "The Effect of Pacing on Output Patterns."

LEE, G. J. 1959. "Pressure and Movement Sensitivity in Drilling Operations."

READ, J. 1959. "Designing a Cutter Dynamometer for Internal Broaching."

SAGAR, V. S. A. 1958. "Machine Interference."

SMEDLEY, R. J. 1957. "A Study of Simultaneous Motions."

SUNDE, R. 1959. "Production Control by Analogue Computer."

INVENTORY CONTROL

A Problem in Stocking Perishable Goods

by Dr. Samuel Eilon, M.I.Prod.E.

Reader in Production Engineering,

Imperial College of Science and Technology.

THE stocking of perishable goods presents some special and interesting problems in inventory control. In the re-order cycle system, the store is replenished to a certain stock level at the beginning of the cycle, and if the demand during the cycle is below the available stock, there would be a certain residue at the end. In the case of perishable goods this residue loses all its value as soon as the new cycle begins. If, on the other hand, demand exceeds the stock available, again a loss would be incurred, since a certain penalty has to be attached to each unit of commodity that cannot be supplied when required (including loss of potential gain and loss of goodwill).

a characteristic example

Stocking of newspapers is a characteristic example of perishable goods. The newspaper has its full value during the day or period for which it is intended, but as soon as the new issue comes out, the old copy becomes obsolete and is usually worthless. Stocking of foodstuffs, certain chemicals, pharmaceutical goods, photographic materials and so on, belong to this class and inventory control of such goods centres round the problem: how much should be produced and how much should be stocked in each period, so that a certain pre-defined objective can be attained (such as minimising the cost of holding inventories in the period specified or maximising the profit when the commodity is intended for sale)?

Some problems relating to the determination of the size of reservoirs are also allied to quantity control of perishable goods. Take, for example, the case of a cinema; the cinema is the reservoir, the seating capacity is "the order quantity" and the number of tickets bought represents demand. If the cinema is full, the management has to turn away potential patrons, so that demand above the prescribed capacity cannot be met, while seats that remain vacant are analogous to left-over goods that cannot be sold. The management of the cinema collects a profit for each seat that is sold, but as the costs of running the cinema are virtually constant, the overheads per seat would represent the cost or the loss to the management for each seat that remains vacant. Here, therefore, is a problem in perishable goods, namely: what is the optimal capacity of the cinema that should be aimed at? Determining the optimum sizes of stores, silos, containers, etc., is essentially a similar problem.

Any analysis of this kind is naturally based not only on the assumption that the distribution of demand is known, but that the future pattern of demand may be inferred from past behaviour. In some of the problems mentioned above—such as erection of a new store—the distribution of demand is not known and has to be assumed from available data about similar stores. Periodic reassessment of the situation may then be made on the basis of current data, so that decisions regarding the modification of the re-order quantity or the capacity of the store may be considered.

the cost function and its optimum solution

If the distribution density function for demand $f(D)$ is known, and if the quantity Q is ordered, the probability that demand will be satisfied (D being smaller than Q) is

$$F=\int_{D}^{Q} f(D)dD \qquad (1)$$

and the probability that demand will not be satisfied (D being larger than Q) is

$$1-F=\int_{Q}^{\infty} f(D)dD \qquad (2)$$

When demand is satisfied, the residual at the end of the period for which demand D is recorded, is $Q-D$. If the loss per unsold unit is c_1, the expected loss for the case $D \leqslant Q$ is

$$\int_{D}^{Q} c_1(Q-D)f(D)dD$$

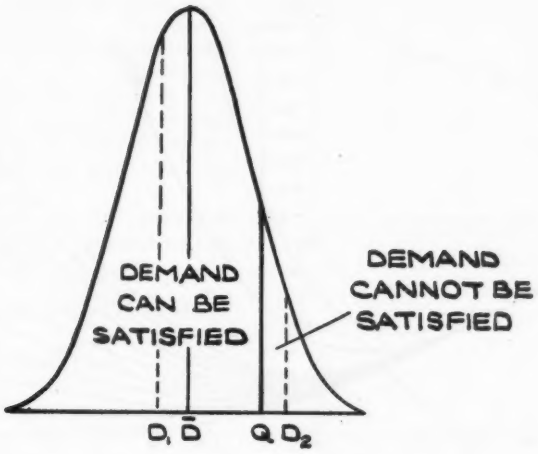


FIG. 1.

A DEMAND DISTRIBUTION f(D)

When $D>Q$, the demand for $D-Q$ cannot be met, and if the penalty per unit that cannot be supplied is c_2, the expected loss is

$$\int_Q^\infty c_2(D-Q)f(D)dD$$

and the total loss is

$$C=c_1\int_D^Q (Q-D)f(D)dD+c_2\int_Q^\infty (D-Q)f(D)dD \qquad (3)$$
$$=c_1F(Q-D_1)+c_2(1-F)(D_2-Q)$$

where D_1 is the average of demand when $D\leqslant Q$, and D_2 is the average of demand when $D>Q$:

$$D_1=\frac{1}{F}\int_D^Q Df(D)dD \qquad (4)$$

$$D_2=\frac{1}{1-F}\int_Q^\infty Df(D)dD \qquad (5)$$

In the case of the normal distribution function it can be shown (Appendix I) that

$$D_1=\overline{D}-\frac{\varphi}{\phi}\sigma \qquad (6)$$

$$D_2=\overline{D}+\frac{\varphi}{1-\phi}\sigma \qquad (7)$$

where $\overline{D}$ is the average demand, φ the normal distribution density function, ϕ the normal cumulative function, δ the standard deviation. ϕ is the accumulative probability from $-\infty$, but as only positive demand values are of interest here, the approximation

$$F\backsimeq\phi$$

may be used and ϕ is obtained from normal distribution tables.

Substituting these relations into (3), the loss function becomes

$$C=c_1\phi(Q-\overline{D}+\frac{\varphi}{\phi}\sigma)+c_2(1-\phi)(\overline{D}-Q+\frac{\varphi}{1-\phi}\sigma) \qquad (8)$$

Denote $$\frac{Q-\overline{D}}{\sigma}=t \qquad (9)$$

and divide the expression for C by σc_2 to obtain the following non-dimensional loss function

$$E=\frac{C}{\sigma c_2}=(\varphi+\phi t)(1+\epsilon)-t \qquad (10)$$

where $\epsilon=\frac{c_1}{c_2}$ is the ratio between the two types of losses.

The loss function E is shown in Fig. 2 for several values of ϵ, including the following two special cases:

$\epsilon=0$ (no loss due to residual stock at end of period or incalculable loss if demand is not met): $E_0=\varphi-t(1-\phi)$ (10a)

$\epsilon=1$ (the two types of losses are the same): $E_1=2(\varphi+\phi t)-t$ (10b)

Those cases where $0<\epsilon<1$ (i.e. the loss due to being unable to supply is greater than the loss per unsold unit) will involve a loss function which lies between E_0 and E_1, but there are many cases where $\epsilon>1$ and the loss function for these will be above E_1.

The loss function E becomes a minimum when

$$\frac{dE}{dt}=0$$

or

$$\left(\frac{d\varphi}{dt}+t\frac{d\phi}{dt}+\phi\right)(1+\epsilon)=1$$

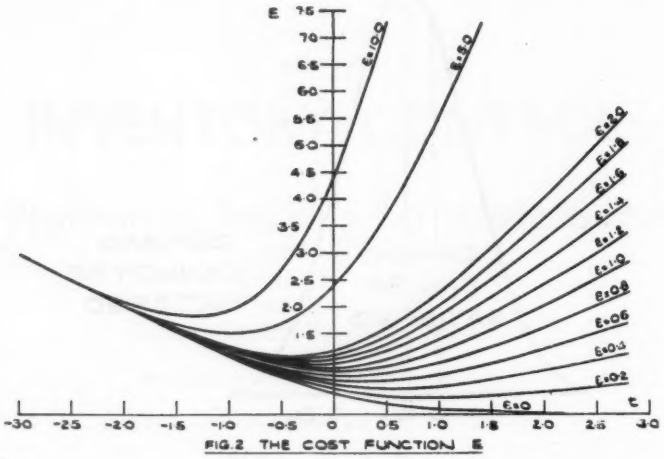


FIG.2 THE COST FUNCTION E

It can be shown that $\frac{d\phi}{dt} = \varphi$; $\frac{d\varphi}{dt} = -t\varphi$

therefore, the optimum solution is given by

$$\phi = \frac{1}{1+\epsilon} \tag{11}$$

For a known value of ϵ(*), the cumulative probability ϕ is calculated by (11) and the corresponding value of t is obtained from the normal distribution tables (the solution is presented in Fig. 3). The optimal quantity to order is

$$Q = \bar{D} + t\sigma \tag{12}$$

No account was made here for storage costs while the goods are in the store, as the underlying assumption has been that the cost for holding a batch in stock for one cycle is constant irrespective of the batch size.

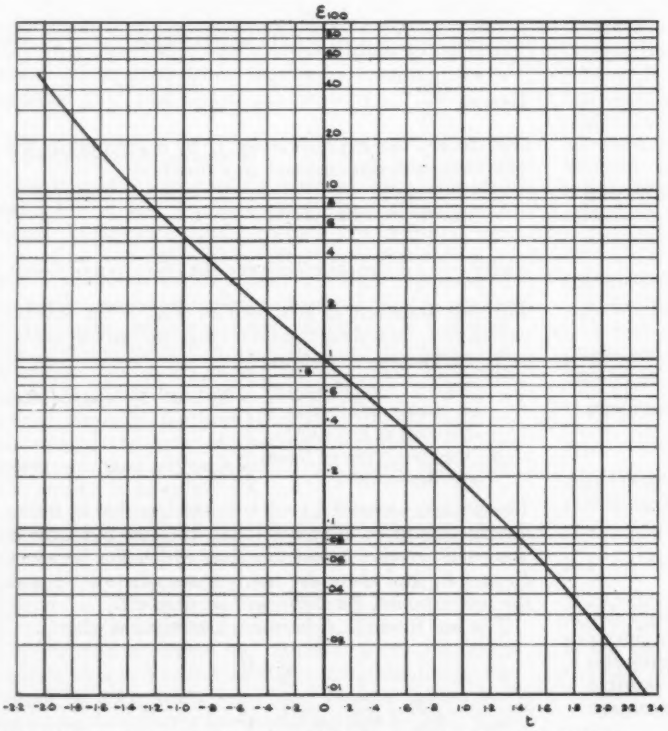


FIG 3. OPTIMUM SOLUTION for STOCKING of PERISHABLE GOODS.

* The value of c_2 is sometimes difficult to establish in practice, since it includes the loss of goodwill, and this is often not a simple factor to analyse quantitatively. Sometimes, management would prefer to define its policy by specifying the percentage of customer satisfaction it is trying to achieve, and this policy may be translated by expression (11) to yield the penalty cost c_2 that is implied thereof.

Indeed, in many cases of perishable goods this assumption is valid, particularly when the storage costs are tied up with the amount of storage space and involve the same amount of attention, maintenance and overhead charged, whether the space is fully utilised or not. If this is not the case, and the storage costs vary with the quantity held in stock, this factor can and should be included in the cost function. Take two examples:

1. Supposing storage involves various operations when goods are received so that the cost could be expressed as $c_0Q=c_0(\overline{D}+t\sigma)=c_0\sigma(\gamma+t)$

   where $\gamma=\frac{\overline{D}}{\sigma}$ is the inverse of the coefficient of variation of the distribution function. The total costs are expected to be

   $$C=\sigma[(\varphi+\phi t)(c_1+c_2)-tc_2+c_0(\gamma+t)]$$

   $$\text{or } E=\frac{C}{\delta c_2}=(\varphi+\phi t)(1+\epsilon_1)-t+\epsilon_0(\gamma+t) \quad (13)$$

   $$\text{where } \epsilon_1=\frac{c_1}{c_2};\ \epsilon_0=\frac{c_0}{c_2} \quad (14)$$

   This cost function is optimum when $\frac{dE}{dt}=0$, yielding the following optimal solution:

   $$\phi=\frac{1-\epsilon_0}{1+\epsilon_1} \quad (15)$$

2. Supposing storage costs may be expressed as c_0 per unit of average stock, the cumulative demand with time being given by the function $\delta(t)$, the average stock level would be (see Fig. 4)

   $$Q-\frac{1}{T}\int_D^T \delta(t)dt \qquad \text{for } D\leqslant Q,$$

   $$\text{and} \quad Q-\frac{1}{T_0}\int_D^{t_0}\delta(t)dt \qquad \text{for } D>Q$$

   and these values can be calculated when the function $\delta(t)$ is explicitly known. When the cumulative demand curve may be reasonably replaced by an approximate linear function the average stock level is $Q-\frac{1}{2}D_1$ for $D\leqslant Q$ and $\frac{1}{2}Q$ for $D>Q$, so that the expected storage costs are

   $$(Q-\tfrac{1}{2}D_1)\phi c_0+\tfrac{1}{2}Q(1-\phi)c_0$$

   Substituting (6) and

   $$Q=\sigma(\gamma+t)$$

   and the storage costs become

   $$\tfrac{1}{2}c_0\sigma(\varphi+\phi t+\gamma+t)$$

   When these are added to the costs given by (8), the following non-dimensional cost function is derived:

   $$E=\frac{C}{\sigma c_2}=(\varphi+\phi t)(\tfrac{1}{2}+\epsilon_1+\tfrac{1}{2}\epsilon_0)-t+\tfrac{1}{2}\epsilon_0(\gamma+t) \quad (16)$$

   and this becomes a minimum when

   $$\phi=\frac{1-\frac{1}{2}\epsilon_0}{1+\epsilon_1+\frac{1}{2}\epsilon_0} \quad (17)$$

maximising the profit

The re-order batch calculated above is optimal when minimisation of the total costs is considered a desirable objective. It has often been demonstrated in operational research problems that an evaluation of a specific system and a proposed optimal solution depend a great deal on the criterion with which effectiveness is to be measured. If different criteria are selected, optimal solutions may be found, and the evaluation of criteria is often in itself a complicated problem. In the case of holding stocks, which are replenished on a re-order cycle system, two situations spring to mind:

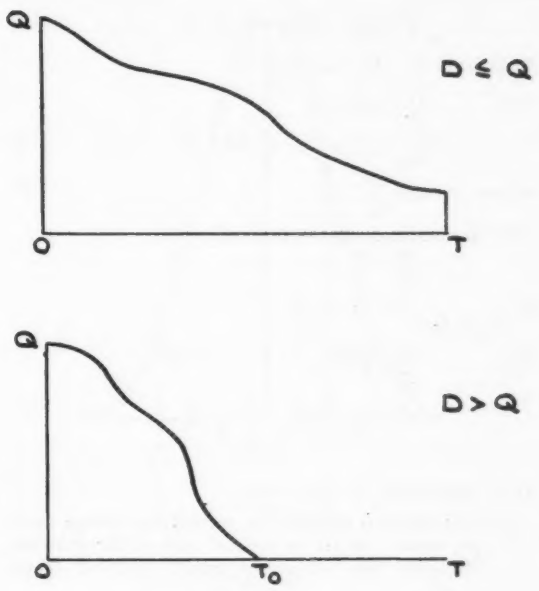


FIG. 4.

1. The stocks are held in order to supply production centres (for further operations or assembly work), other stores, maintenance schedules, etc., but they are not held for the purpose of direct sales. In other words, it would be either impossible or impractical to specify how much "profit per unit" is expected. In such cases it would seem that minimising the total costs of holding stocks is the logical objective to specify.
2. The stocks are held for the purpose of satisfying immediate customer demand and the sale of each unit yields a certain profit. In this case, profit maximisation would seem a desirable objective. What re-order quantity should, then, be aimed at?

Supposing the difference between the production or acquisition costs and the sales price is z per unit, the total gain would be

$$z\int_0^Q Df(D)dD=zD_1\phi \quad \text{when } D\leqslant Q$$

$$z\int_Q^\infty Qf(D)dD=zQ(1-\phi) \quad \text{when } D>Q$$

and as the cost of carrying the stock is C, the total profit would be

$$P=z[Q-\phi(Q-D_1)]-C \tag{18}$$

Substitute $Q-D_1=\sigma(t+\frac{\varphi}{\phi})$

and $Q=\sigma(\gamma+t)$

$$\therefore \frac{P}{\sigma c_2}=\zeta(\gamma+t-\varphi-t\phi)-E \tag{19}$$

where $$\zeta=\frac{z}{c_2} \tag{20}$$

and maximum profit is obtained when

$$\frac{dP}{dt}=0$$

or $$\zeta(1-\phi)=\frac{dE}{dt}$$

but $$\frac{dE}{dt}=\phi(1+\epsilon)-1$$

$$\therefore \phi=\frac{1+\zeta}{1+\epsilon+\zeta}=\frac{1}{1+\frac{\epsilon}{1+\zeta}} \tag{21}$$

It is interesting to note that:—

1. The optimal solution for minimum storage costs per unit is in fact a special case of the solution obtained for maximum profit (derived when $\zeta=0$).
2. The solution (21) may be represented by Fig. 3, only now ϵ is substituted by $\frac{\epsilon}{1+\zeta}$ in the abscissa.
3. As $\frac{\epsilon}{1+\zeta}<\epsilon$ for $\zeta=0$, the solution for maximum profit yields a higher value of ϕ (and hence a higher re-order quantity Q) than the optimal solution for minimum costs.

non- and semi-perishables

This analysis may also be applied to non- and semi-perishable goods. Non-perishables are goods or materials that do not noticeably lose any value by remaining in stock, so that a residual stock at the end of the cycle is simply transferred to the next cycle. If the stock can be replenished at a very short notice and it is so arranged that the stock level is brought up to a constant value Q at the beginning of the cycle, the expected level of residual stock is

$$\begin{aligned} R&=\int_0^Q (Q-D)f(D)dD \\ &=(Q-D_1)\phi \\ &=\sigma(\varphi+\phi t) \end{aligned} \tag{22}$$

The amount ordered for replenishment will be Q minus the actual residual stock at the end of the cycle. In most cases, however, replenishment cannot be attained at short notice and the re-order batch has to be specified long before the actual level of the residual stock is known. If the re-order batch is X, the expected residual stock is given by

$$R=\int_0^{X+R} (X+R-D)f(D)dD \tag{23}$$

but the solution of (23) is more involved than (22), since $Q=X+R$ is now a variable and not a constant as in the case of perishable goods. The cost function for non-perishables would be similar to (3), and it is obvious that with no storage costs to take count of and no losses due to left-over stock (i.e. $c_1=0$), the cost function is dependent only on the penalty costs for not meeting demand, and these costs become minimum when $Q\to\infty$ (as implied by (10a). However, when storage costs are included in the analysis, for instance, in the form of c_0 per unit received, the cost function would be

$$C=c_2\int_Q^\infty (D-Q)f(D)dD+c_0Q \tag{24}$$

where the variable $Q=X+R$ and R is given by (23).

Semi-perishables can be similarly analysed. Semi-perishables may be defined as goods that neither lose nor retain their full value at the end of the cycle. If the residual at the end of the cycle is disposed of (for instance, by resale in bulk to another firm, or by returning the residual to the supplier or manufacturer and being reimbursed at a certain percentage of the price), the stock level at the beginning of the cycle would solely be determined by the re-order batch and can be kept constant. The above analysis for perishable goods would then apply, only c_1 would stand for that value of each unit that is lost at the end of the cycle (which corresponds in the case of perishable goods to the full acquisition value of the article).

If, however, the residual at the end of the cycle is not disposed of, but retained in stock, there would be two kinds of goods in the next cycle: fresh goods, which are first-rate and have the full value, and old goods, which are second-rate and have a somewhat lower value. When these goods are stocked for sale and the second-rate ones are sold at a lower price than first-rates, the consumption or demand for fresh goods may be greatly affected by having old goods in stock; this factor would in turn affect the amount of residual stock that management is prepared to tolerate, and hence the re-order quantity that should be specified.

Naturally, it is necessary to distinguish between two situations, the one where the customer has a free choice to select fresh or old goods, and the other where the issuing sequence may be determined by internal considerations alone. In both situations, a profit or a cost function can be set up, very much on the same lines as indicated above, but the determination of an optimal re-order batch will greatly depend on the derivation of solutions for such complicated functions as (23). In the case of free choice by the customers, the analysis must include a function describing the distribution of preferences, and simulation techniques may be very helpful in solving this type of problem.

When the issuing sequence is not governed by external choice, the determination of an optimal sequence is often quite a straightforward procedure. Supposing there are in stock Q_1 fresh units, which—if left over at the end of the cycle—would lose c_1 in value per unit, Q_2 units which are one cycle old and which would lose c_2 in value per unit if transferred to the next cycle, etc. If the store has the choice of selecting the items for issue, it will obviously single out for immediate issue that group which is likely to lose the highest value per item. The proof is fairly simple: If

there are two groups of such items, Q_1 fresh goods and Q_2 old ones, and if the demand for the cycle is D units, of which D_1 are taken from the new stock and D_2 from the old stock, the total loss at the end of the cycle will be

$$L=(Q_1-D_1)c_1+(Q_2-D_2)c_2$$

but $D_2=D-D_1$

$$\therefore L=Q_1c_1+Q_2c_2-Dc_2+D_1(c_2-c_1)$$

and $$\frac{dL}{dD_1}=c_2-c_1$$

If $c_2=c_1$ the loss will be independent of the sequence of issue; if $c_2>c_1$ then $\frac{dL}{dD_1}>0$, or L is an increasing function of D_1, so that D_1 should be reduced as much as possible and the old stock should be earmarked for first issue; if $c_2<c_1$, fresh stock should be issued first. When there are n groups and the loss after each cycle is indicated by a step function as in Fig. 5, then by induction the rule would simply be: arrange the loss values c as a diminishing order series; this order specifies the optimal sequence of issue and no group should be issued before the one preceding it in the series has been completely depleted.

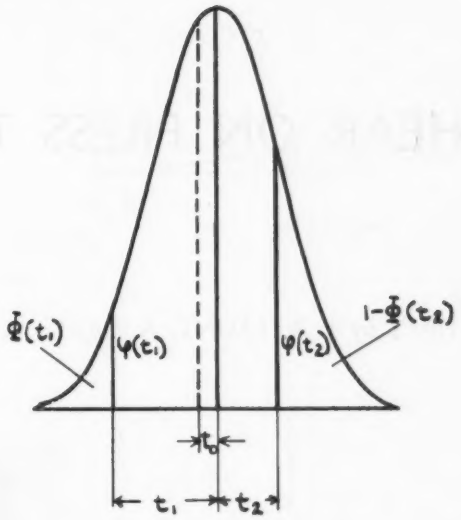


FIG. 5

conclusions

The analysis presented in this Paper is applicable to perishable goods and to semi- and non-perishables which are replenished to a given level each cycle and in principle the same approach may be used, when the stock level at the beginning of the cycle tends to fluctuate due to the effect of the residual stock at the end of the previous cycle. Although the analysis was confined in the main to normal distribution of demand it should cover quite a wide field, especially as the actual type of the distribution function appears to have a lesser effect on the optimal solution as the percentage of satisfaction in meeting demand goes up. Considering the enormous number of goods in industry and in the retail business that may be classified as semi-perishables, it would seem that a further study in this field should definitely be worthwhile.

APPENDIX I (see Fig. 5)

The normal distribution density function is given by

$$\varphi(t)=\frac{1}{\sqrt{2\pi}}exp(-\tfrac{1}{2}t^2)$$

and the cumulative distribution from $-\infty$ to t is

$$\phi(t)=\int_{-\infty}^{t}\varphi(t)dt$$

where $t=\frac{D-\overline{D}}{\sigma}$. The cumulative distribution between two limits t_1 and t_2, where $t_2>t_1$, is $\phi(t_2)-\phi(t_1)$ and if the average value of the variable t between these limits is denoted by t_0, then

$$t_0[\phi(t_2)-\phi(t_1)]=\int_{t_1}^{t_2}t\varphi(t)dt$$

$$=\frac{1}{\sqrt{2\pi}}\int_{t_1}^{t_2}t\,exp(-\tfrac{1}{2}t^2)dt$$

$$=\frac{1}{\sqrt{2\pi}}\int_{t_1}^{t_2}exp(-\tfrac{1}{2}t^2)d(\tfrac{1}{2}t^2)$$

$$=-[\varphi(t_2)-\varphi(t_1)]$$

$$\therefore t_0=-\frac{\varphi(t_2)-\varphi(t_1)}{\phi(t_2)-\phi(t_1)}$$

Hence, the average tD_1 from $-\infty$ to Q is obtained by substituting $t_1=-\infty$ and $t_2=t$, or

$$tD_1=-\frac{\varphi(t)}{\phi(t)}$$

$$\therefore D_1=\overline{D}-\frac{\varphi(t)}{\phi(t)}\sigma$$

Similarly, the average tD_2 from Q to ∞ is obtained by substituting $t_1=t$ and $t_2=\infty$,

$$\therefore tD_2=\frac{\varphi(t)}{1-\phi(t)}$$

and $$D_2=\overline{D}+\frac{\varphi(t)}{1-\phi(t)}\sigma$$

SHEAR ON PRESS TOOLS—

A NEW APPROACH

A Thesis by J. A. SAUNT, A.R.Ae.S., A.M.I.Prod.E., M.I.Plant.E.

Senior Development Engineer,

Lightning Fasteners Ltd.,

Witton.

A FEW years ago the writer was faced with the task of producing a considerable quantity of pressings, of a variety of types, for electrical equipment, although having no previous experience of press tool work or pressing manufacture. A number of well-known works on presswork were studied, but wide deviations of opinion between writers on many salient points gave rise to some misapprehension. Owing to severe limitations of equipment, together with requirements of the job in hand, it was essential to make use of the advantages of sheared tools without being subject to the disadvantages credited to them by some authorities.

Disregarding, to a great extent, the published information, and working from first principles of the mechanics of cutting sheet metal, a method of applying shear was devised which appeared to have more advantages than, with none of the drawbacks of, existing methods. Experience proved the theory substantially correct, and at a later date a more extensive study of the question of shear was embarked upon. Much interesting detail came to light, making it possible to formulate definite opinions not only on the published information, but also on what further is required to put the practice of shearing press tools on a sound basis.

This Thesis is of necessity highly condensed, and it is hoped to deal with the matter at greater length in textbook form at some future date.

current ideas and practice

the generally accepted practice

The application of shear to a press tool will result in a reduction in the maximum blanking load, with consequent reduction in the loads imposed on the tools and machines. Despite the apparent advantages, few authorities deal with its theory and application in an analytical manner, and tend to regard it largely as a useful expedient to enable a smaller press to be employed in an emergency. A variety of disadvantages are stated to accompany its use. One writer only advocates its use as a general policy.[7]

application and calculation

There are two common methods (with minor variations) of applying shear to press tools. These are :-

Single Shear

(Fig. 1a.) The face of the punch or die is inclined from one side to the other. It is sometimes recommended that the leading point of the punch be flattened (Fig. 1b) [8]. No indication is given as to position of leading point.

Double Shear

(Fig. 2a.) The punch face is inclined up and outwards from either side of centre line, or die face down and outwards. No indication is given as to direction of centre line. Sometimes the centre ridge is flattened (Fig. 2b).

Writers generally agree that the material in contact with the "sheared" face of the punch will be distorted by the punching operation; shear must therefore be on the face contacting what will be the scrap. One writer states that distortion is less likely if the amount of shear is less than the stock thickness [7].

Little guidance is available as to the amount of shear required for a given result. It is generally taken that 100% shear, i.e., equal to stock thickness, gives a reduction in maximum load of 30 - 35% for thin material, 25% for thick. Methods of calculation are vague and unreliable. Some writers recommend leaving all decisions on shear to the toolmaker [14].

Many inconsistencies are found in writings on the application and calculation of shear. Single shear is said to induce "side kick" or "side thrust" [8] of the punch, but no explanation is given as to what side kick is. There appear to be two possible explanations. The first is that as the leading edge of the punch strikes the stock it will tend to tilt the punch and ram, causing the punch to foul the die. If a dieset is used, or the clearance between ram and slides is within prescribed limits [11], such tilting would not be possible. The advice of some against single shear on the grounds of offset load, does not fit in with the advice of others to flatten the leading point of the punch, which would aggravate the trouble. Observations have shown that if the punch strikes the stock within the projected area of the ram face, tilting is not likely to occur irrespective of the press condition. The second line of thought is that the "inclined plane" action of punch face on stock will cause sideways movement. In Fig. 3 :-

W = Downward pressure of punch
P = Pressure between punch and stock normal to sheared face
R = Resultant force tending to move punch sideways
a° = Angle of sheared face
μ = Coefficient of friction between punch and stock

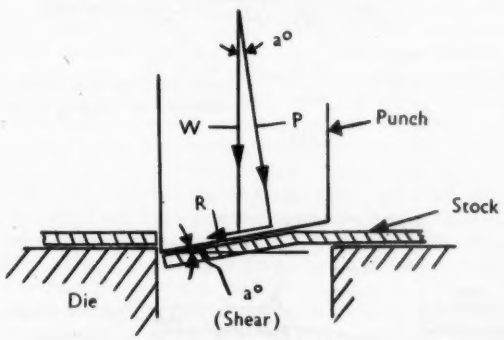


Fig. 3.

"SIDE THRUST" ON SINGLE SHEARED PUNCH

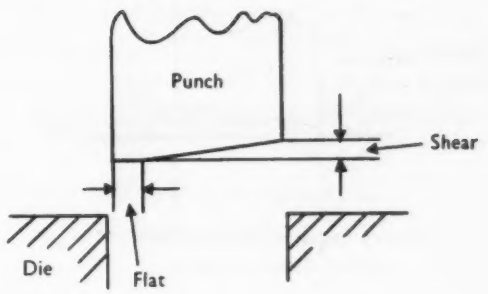


Fig. 1(b).

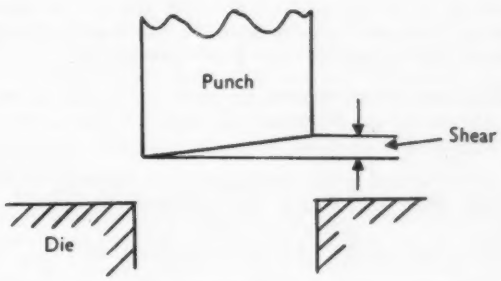


Fig. 1(a).

SINGLE SHEAR

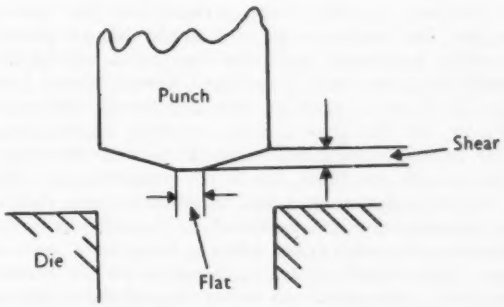


Fig. 2(b).

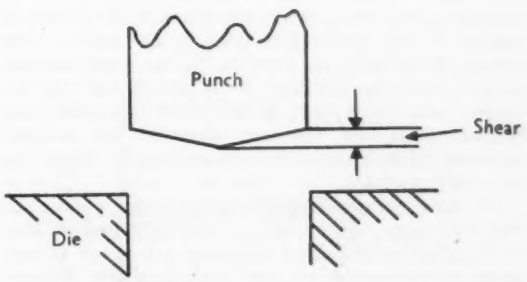


Fig. 2(a).

DOUBLE SHEAR

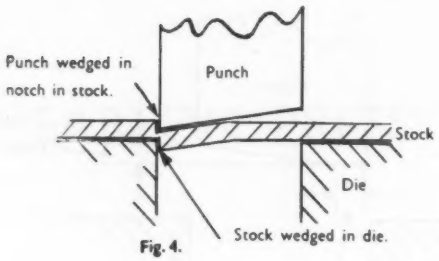


Fig. 4.

now P = W cos a°, and R = W sine a° = force tending to move punch sideways, but force resisting movement of punch $= \mu$ P = μW cos a°.

Therefore for movement to occur
W sine a° $> \mu$ W cos a°
or sine a° $> \mu$ cos a°.

Under normal press conditions μ is unlikely to be lower than 0.25 6 and the equation becomes
sine a° > 0.25 cos a°
which can only be when a° is greater than 14°.

This angle of shear would never be reached in blanking punches. Some forming punches have their faces angled considerably above 14°, but no writer mentions the possibility of these being forced sideways.

However, careful study reveals that on initial impact, the leading edge of a single sheared punch partially penetrates the stock forming a seating for itself, whilst the part of the blank already forced into the die forms a positive stop against the die edge (Fig 4). By the time a load anything approaching that necessary to cause "side kick" has built up, both punch and blank are firmly located in the die.

At this point, it is as well to consider press design in relation to the possibility of punch tilt. The modern transverse crank press is designed in such a way that immediately a load comes on the punch the ram is forced into its wedge shaped slides, taking up all play, and effectively preventing any sideways movement or rocking of the ram and punch. In the older open front presses, although the ram fits in dovetail slides, the action of the crank tends to induce rocking of the ram when there is no load on the punch, there being no force to induce a centralising action. Also, the distance from punch face to the nearest point of support of ram slides is considerably greater, press size for size, than in the modern machine. Slide clearances too are usually larger on the older machine.

All these factors combine to produce conditions that will cause any punch to rock and foul its die. With a flat faced punch, snipping can occur at any point on its periphery, but with a single sheared punch, if rocked so that the heel of the shear could foul (Fig. 5a), the action of the punch would trap metal between the heel and the die face, forcing the punch into line with the die aperture. If rocked so that the leading edge could foul (Fig. 5b), it would do so, the stock being forced away from the punch by the shape of the lead, leaving the punch to strike the die. Thus, single sheared punches would show more frequent snipping at the leading edge, giving rise to the belief that it was the shear causing the punch to run sideways, not the inherent rock of the press ram. This line has undoubtedly been accepted as fact by a substantial body of writers, without the validity of the argument being tested using modern presses and diesets.

Inconsistencies occur in writings on double shear, and though this method is generally recommended, investigation reveals it to be less satisfactory than single shear. It is stated to achieve both balancing of punch load, and centralising of punch. It is agreed that the punch load is balanced about the central ridge, but this ridge is not necessarily under the centre of pressure of the press ram, and any initial offset of the load is maintained throughout the operation, unlike single shear in which the line of pressure moves across the blank. As the punch does not contact a matching seating, but produces its own, centralising effect of the wedge shaped face is non-existent.

If the punch is offset on striking the stock, it will remain offset until the heel of the shear on one side rides on the die face and is forced sideways, probably snipping the die. Snipping of double sheared punches and dies was observed to be most frequent on circular tools at a point about halfway along the sheared edge, indicating that centralising was effected by the punch fouling the die, not by the double shear.

Tests have shown that though double shear decreases the maximum blanking load, it also increases the amount of work done in producing a

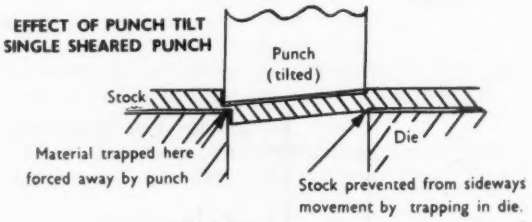


Fig. 5(b).

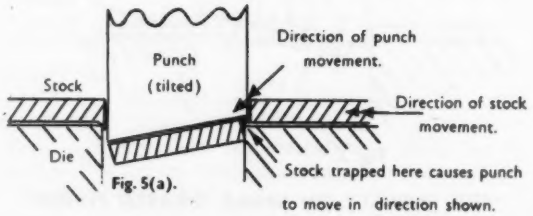


Fig. 5(a).

given blank; it also increases waste, and can give incorrect sizing to the blank, or aperture in the stock. Studying the action of a double sheared punch shows that as the shearing action moves outwards from the central ridge, the blank is being formed over the face of the punch (Fig. 6). The distance between the points of shear around the face of the punch is greater than that between the same points along the face of the stock; consequently the blank must be stretched, as also must the stock where the blank is still attached. The load on the punch necessary to stretch the metal can be calculated and the work of stretching is close to the increase in blanking work recorded in Chang's "Shearing of Metal Blanks" 5. This extra work is entirely wasted, whilst the stretching of the blank and stock sets up undesirable strains in the finished part.

The bending of the metal over the sheared face renders it useless for smaller blanks, so preventing metal conservation. Because of the bending experienced with double sheared punches particularly, recommendations are frequently found to put the shear on the die if the blank is the required part, and *vice versa*. Grinding of shear on a die is not to be recommended under any circumstances, as it takes away the firm support necessary to make clean and accurate punchings. It can also be an extremely awkward procedure, particularly with follow on tools. To put single shear on a die is mathematically incorrect, as it will result in producing an oversize blank which must be forced through a correct sized hole (Fig. 7).

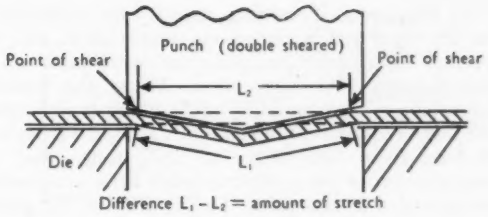


Fig. 6. STRETCHING AND FORMING AROUND DOUBLE SHEARED PUNCH.

some factual observations

A considerable number of press operations were studied in a variety of shops, and many individuals closely connected with presswork for up to 40 years were questioned, with interesting results. Of the tools inspected only one, a slotting punch, had single shear. The others were approximately 50/50 flat and double sheared. The latter were roughly 70/30 punch and die sheared. All subjects were asked why they did not use single sheared tools, and all gave the same arguments put forward in the various textbooks. All were then asked if they had ever used single sheared tools, if so, when, and with what result. With the exception of the operator using the slitting tool mentioned above, none of the subjects had ever used single sheared tools.

The user of the slitting tool was asked if he had ever experienced any of the troubles attributed to single sheared tools. He had not, but for some undefined reason would not accept that the tool in question had single shear. In view of the answers to the second question, all were asked why they were so positive with their first answers when they had no practical experience to guide them. The answer invariably was that "it was what they had always been told".

One particular job closely scrutinised was a disc, approximately 12 in. dia., of 12G medium carbon steel, hard rolled and planished. Concentric circles of perforations of various shapes were punched in a series of operations. Some of the punches were double sheared, the rest flat. These discs were required flat within close limits, necessitating periodic hand smithing during manufacture. Long experience determined that smithing be done after certain operations, distortion being then most pronounced, but it had never been realised that excessive distortion always appeared after an operation using double sheared punches.

In this same shop large numbers of rings were manufactured, the centres being removed using double sheared punches. These centres varied from 4 - 9 in. dia., in materials up to $\frac{1}{4}$ in. thickness. All became scrap due to bending by punch. Punching out flat would have enabled them to be used for smaller rings in production.

conclusion on general investigations

It is evident that there is a considerable amount of incorrect thought on the question of shear, apparently due to continued acceptance of ideas of long standing which have no sound basis in theory or modern practice.

a new system — "continuous shear"

basic reasoning

The simplest form of metal shearing machine is the hand-operated guillotine; a study of its construction and operation provides information of considerable value when designing press tools (which can be regarded as more advanced forms of guillotine, in that they cut out shapes instead of only cutting along one line).

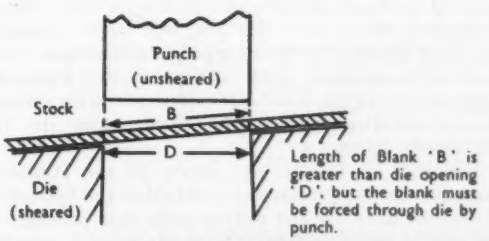


Fig. 7. EFFECT OF SINGLE SHEAR ON DIE.

In relation to its cutting capacity the guillotine is far less rigid and heavily built than a press, e.g., the average light bench guillotine can accomplish a 6 in. cut through 16G M.S. sheet. Using the formula for accurate determination of blanking load [12] gives the force required to press a blank having a periphery of 6 in. from 16G M.S., as 9.177 tons — but the construction of the guillotine bears little relationship to that of a 10-ton press. This is because the guillotine uses the principle of single shear, the two blades being mounted to give a scissor action, so reducing the maximum load on the cutters and dispensing with the necessity for heavy construction. The shear action eliminates shock loading and unloading, giving smooth and reasonably quiet cutting; punching a blank in a press with an unsheared punch creates two distinct shocks, accompanied by a large volume of noise.

A check was made to determine whether the amount of work done in making a given length of cut varies as between guillotine and press. According to Chang [5], 2.7 in. tons of work were done in cutting a 6 in. dia. blank from 0.126 in. M.S., using an unsheared punch. Proportionally this gives 962 in. lb. as the work done in making a cut 6 in. long through 16G M.S. using parallel, i.e., unsheared, cutters. Allowing for punch curvature and withdrawing load, the work done on the straight cut would be in the vicinity of 900 in. lb. Experiments were carried out on a guillotine cutting strips from 16G M.S., 6 in. wide. The load applied to the handle was measured by spring balance, the distance travelled by the point of application of the load being also measured. Results gave an average load of 22 lb. travelling through 38 in. to complete the cut, i.e., work done was 836 in. lb. The observations were not extensive or accurate enough to prove conclusively that less work is done cutting with sheared blades, but they do indicate that there is a possibility that this may be so.

effect of blade clearance

The effect of blade clearance was next studied. Considerable research has been done regarding punch/die clearances [5, 8, 11, 12, 13], with definite conclusions, but all experiments were based on unsheared punches and dies. Nevertheless, similar clearances are usually advised for guillotines. Observations show that the cleanest and most effortless cuts on guillotines are made when the blade clearance is nil, i.e., the blades lightly rub each other. This corresponds to experience with hand shears — as long as the blades are in continuous light contact cutting is clean and effortless, but when clearance develops cutting becomes ragged and laborious. With unsheared punches lack of punch/die clearance increases stripping load, but experience with sheared punches indicates that the same rules do not necessarily apply.

Evidence so far on the action of the guillotine gives rise to the question as to whether the behaviour of the metal being cut differs from that revealed in the numerous experiments with unsheared punches and parallel cropping blades. The usual pattern of behaviour with unsheared cutters is an initial compression of the metal accompanied by surface fracture at the cutter edge, followed by a stretching across the line of cut, then complete rupture of the stretched metal, assisted by the cutter edges. The nature of the fracturing action is such that clearance is necessary to prevent formation of a secondary tongue in the fracture, which must be sheared after the main shearing cut. It is the sequence of compression-stretch-fracture which is important. When the cutters have a scissor action the cut becomes progressive across the metal, as with a lathe tool or milling cutter, and the behaviour of the metal could conceivably be the same as when operated upon by those tools. This point requires further investigation.

Bending of the cut-off piece was next studied. Due to their elasticity most metals can stand a certain amount of deflection without set. The amount of this deflection is dependent on the length, thickness, and mechanical properties of the specimen. When the deflection is caused by the blades of a guillotine, the length over which the deflection takes place is determined by the relative angle of the blades, i.e., the shear angle. Thus, for any given material the relationship between shear angle and thickness will determine whether bending will occur when cut. This relationship would appear to remain fairly constant, and bearing in mind the characteristics of the metals handled in presswork it is reasonable to assume that the softer ones would be bent by smaller angles of shear than the harder metals. This rule does not necessarily apply to non-metallic materials.

On a hand guillotine with straight blades the angle of shear decreases as the blades close. This feature was used to check the above conclusions. Cuts were made in a variety of specimens of varying thicknesses, using different sections of the blades to obtain different shear angles. The tests supported the conclusions, and indicated that, in general, metals up to 0.080 in. thickness could stand a shear angle of 3 - 4° without bending.

The limiting shear angle without bending for different metals and materials requires research and tabulation.

Lastly, the problem of twisting of pieces cut off by the guillotine was caused by one or more of the following :- (1) clearance between blades; (2) blunt blades; (3) blade edges having excessive bevel. In a blanking tool (1) would be necessary, but would be balanced out by the two sides of the tool; (2) can be corrected; (3) would not occur.

One other factor of metal behaviour must be considered before designing a press tool incorporating shear. This is the amount of penetration required to effect complete severance of blank from stock. Information on this matter is very limited and its accuracy sometimes questionable. Only one writer has made a real attempt to produce a comprehensive graph covering a number of materials and thicknesses [8], (Fig. 27), though outside a small range it is obviously inaccurate. It does in fact indicate that with all metals covered there is a thickness at which complete severance is accomplished without penetration and, if extended, the graph would even show

severance without impact above a certain thickness.

This factor of penetration to effect complete severance requires further research and recording. In the absence of reliable information it is frequently necessary to rely on intelligent deduction.

result of observations on guillotine work

From observations made it was deduced that flat blanks could be produced with single sheared punches, leaving the remaining stock flat, provided that the shear angle on the face of the punch does not exceed the limiting angle for deflection of the material being punched. In the absence of reliable figures this angle should not exceed 3°, though this amount will rarely be necessary.

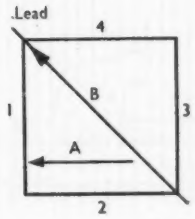
continuous shear

method of application

In the early paragraphs of this Thesis it was pointed out that when dealing with single shear, writers show it as from left to right, or front to back, not specifying the location of the leading point. Except for circular tools this means that some edges of the punch may not be sheared at all, so the full advantage of shear is not felt. The underlying principle of continuous shear is that the punch must make point entry into the metal, and the shearing action must run from this point progressively along both sides of the blank without ceasing, eventually converging until the blanking action is completed at a single point.

To achieve this the "shear line" on the punch must first be determined. This is the line indicating the direction of slope of the sheared face and its direction is governed by the shape of the blank. Fig. 8 shows the face of a square punch. If single shear is given in the direction of arrow "A" the punch will strike the stock with the full length of side 1 (which is not in shear); the shearing will then travel along sides 2 and 4 until side 3 strikes with its full length, completing the operation. This gives shock loads at entry and exit with a small load in between. With the shear line in the direction of arrow "B" true continuous shear is obtained. The punch enters at the junction of sides 1 and 4, the shearing action travels along those sides, then back along sides 2 and 3, finishing at the remaining corner. Thus it starts with minimum load, builds up to maximum, then decreases again to minimum at the end of the operation. There is no entry or exit shock, and the smooth rise and fall of load creates a minimum of strain on the machine.

The square provides a perfect example of continuous shear, but the principle applies whatever the shape — start and finish on a point, never a line. The shear line must be positioned so that no section of the periphery is at or near right angles to it, and must be as long as possible, ensuring that the shearing action builds up smoothly. A graticule as shown in Fig. 10, scribed on a piece of transparent material, is of considerable help in deciding the position of the shear line on the punch drawing. When the direction is settled the leading end must be decided upon. If the blank is reasonably regular either end can lead,



Arrow 'A' — Conventional shear; sides 1 & 3 unsheared, sides 2 & 4 in shear.

Arrow 'B' — Continuous shear; all sides subject to shear. This arrow is the "shear line"

Fig. 8. EFFECT OF DIRECTION OF SHEAR ON SQUARE PUNCH.

but if the major portion of the periphery lies towards one end the opposite end should lead. This avoids putting the major load on the press until the crank is in the best position to withstand it, i.e., near B.D.C.

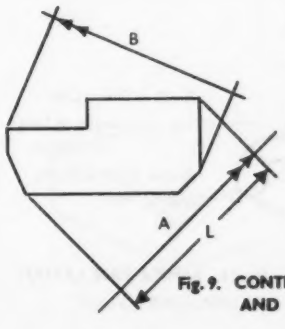
method of calculation

The shear angle is calculated in relation to the shear line and the "length of shear", (referred to below), is the length of the punch when projected on to the shear line (Fig. 9). In all the calculations "Penetration for Complete Severance" is expressed as a measurement, not as a percentage.

To calculate the shear angle for a given result
(The figures used in this example are from an actual case.)

Material : Hard Rolled Brass.

S = Ultimate Tensile Strength = 28 tons/sq. in.
T = Thickness = 0.048 in.
F = Shear Factor = 0.8412
P = Penetration for complete severance = 60% of 0.048 in. = 0.029 in.
C = Periphery of blank = 7.1 in.
L = Length of Shear = 1.625 in.
Lp = Maximum permissible press load = 3 tons
Lm = Blanking load with unsheared punch = C × T × S × F12
A = Cross sectional area in shear = L × T
B = Length on shear line of maximum permissible area in shear



Arrows 'A' & 'B' show two possible shear lines on punch . . . . The head of the arrow shows leading end. 'B' is the better line as it is the longer of the two.

'L' is the "length of shear" (in the case of line 'A') i.e., "the projected length of the punch on the shear line".

Fig. 9. CONTINUOUS SHEAR APPLICATION AND NOMENCLATURE.

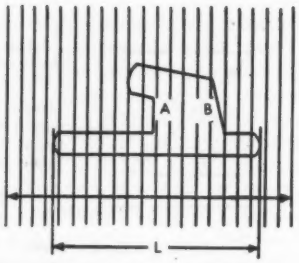
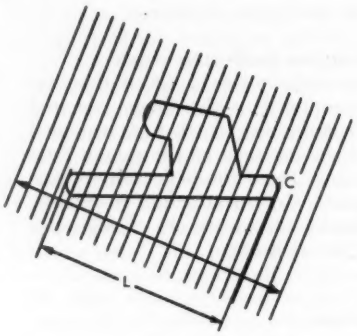


Fig. 10. USE OF GRATICULE

Longest possible shear line but sides 'A' & 'B' at or near right angles to shear line — not good.

Shorter shear line than above but no edges near right angles to shear line — use this one. Lead at 'C'.



Referring to Fig. 12, if the punching was done by a flat faced punch the whole of the area $L \times T = A$ would be in shear; but the maximum permissible press load limits the area in shear at any one time to $\frac{Lp}{Lm} \times A$. When a sheared punch penetrates the stock, load on any point of the punch edge ceases as soon as that point has penetrated the amount P. Therefore the area in shear at any time is the area directly below and between the point of zero penetration "o", and P penetration "m" of punch edge (shown shaded), and this area $= B \times \frac{(T + (T-P))}{2}$ which in this case also $= \frac{Lp}{Lm} \times A$.

$$\therefore B = \frac{Lp \times A \times 2}{Lm \times (T + (T-P))}$$

By resolving the triangle m–n–o the necessary angle of shear E° can be found.

$$\therefore \text{Tangent } E° = \frac{on}{mn}$$

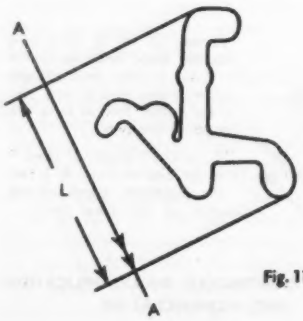
But, on = P and mn = B

$$\therefore \text{Tangent } E° = \frac{P}{B} = \frac{P}{\frac{Lp \times A \times 2}{Lm \times (T + (T-P))}}$$

$$= \frac{P \times Lm \times (T + (T-P))}{Lp \times A \times 2}$$

Substituting for Lm and A =

$$\frac{P \times C \times T \times S \times F \times (T + (T-P))}{Lp \times L \times T \times 2}$$



A – A = Shear Line
L = Length of Shear = 1.625 in.
Arrow Head indicates leading end.

Fig. 11. SAMPLE CASE LAYOUT.

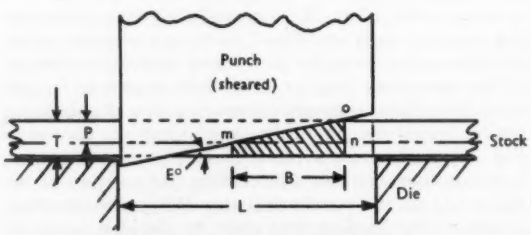


Fig. 12. CALCULATING ANGLE OF SHEAR

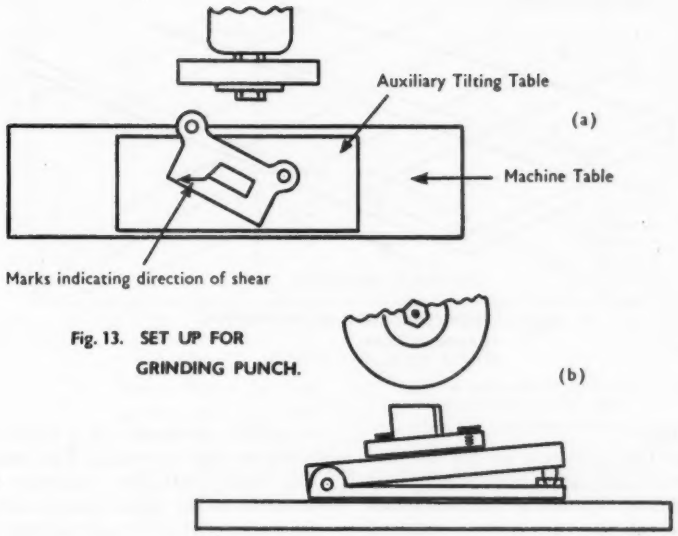


Fig. 13. SET UP FOR GRINDING PUNCH.

Simplifying Tangent E° =

$$\frac{P \times C \times S \times F \times (T + (T\text{–}P))}{Lp \times 2L}$$

Substituting known figures Tangent E° =

$$\frac{0.029 \times 7.1 \times 28 \times 0.84 \times (0.048 + (0.048\text{–}0.029))}{3 \times 2 \times 1.625}$$

$$= 0.029 \times 7.1 \times 14 \times 0.28 \times \frac{0.067}{1.625}$$

$$= 0.03329$$

$$\therefore E° = 1° \ 54' = \text{angle of shear.}$$

This is the minimum angle assuming the periphery to be evenly distributed, but as this is a complex shape not too evenly disposed it is advisable to allow a safety margin of approximately 20%, making the angle 2° 17′. This latter amount could be slightly adjusted to suit the most convenient graduations on the grinding equipment.

The direction of the shear line should be clearly shown on the punch, holder, or dieset. To grind the shear angle correctly it is then only necessary to place the punch in its holder, or dieset, inverted on the table of the grinder, align, then tilt the auxiliary table the required angle. (Fig. 13.)

effects of the new system *on tool design*

Due to the continuous shearing action there is no tendency to build up bursting pressure in the die as with an unsheared punch. Consequently the die can be made from much lighter section material. All the dies used in the tests and production runs were made from $\frac{1}{4}$ in. thickness ground flat stock, backed up with a $\frac{3}{8}$ in. thickness mild steel bolster. It was found that die apertures could be as close as $\frac{3}{4}$ in. to the plate edge without danger of splitting. The thin plates made working out of the dies a much simpler operation, and reduced material costs. Heat treatment was made much easier. Punch die clearances can be reduced to a minimum irrespective of material or thickness, facilitating correct size maintenance of the finished parts; the stripping force is less than with other types of punch, dropping practically to zero as soon as the "heel" of the shear is clear of the stock, therefore stripper plates can be less robust. The sharp leading point of the punch has not been found to be subject to any greater wear than the punch face. The net result is a much more compact and lighter tool, which can often be fitted in a smaller dieset, showing an all-round saving in costs.

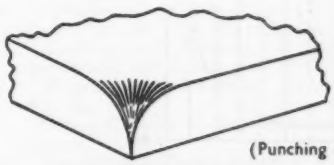


Fig. 14. RADIUSING OF EXIT CORNER.

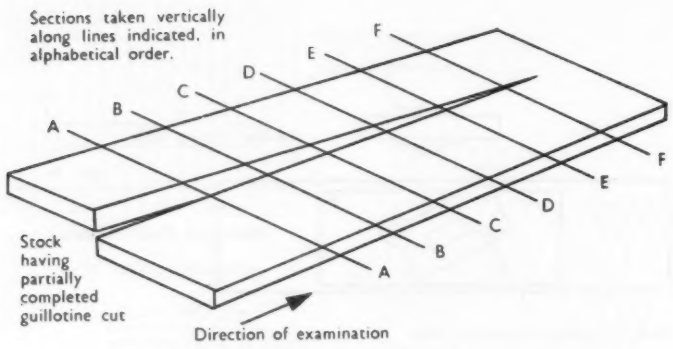


Fig. 15. PROCEDURE FOR MICROGRAPHIC EXAMINATION.

on punching operation

The slight tilting of the punching in the die has not been observed to have any unwanted effects, and frequently assists in clearing. Punching becomes much smoother and quieter; shock vibration is reduced to a relatively negligible amount. The reduction in noise and vibration simplifies problems of insulation where of necessity presses must operate in close proximity to offices and other departments in which work can be seriously hampered by these conditions.

on finished blank and stock

Blanks are invariably flat, showing no tendency to "dish" as frequently occurs with a flat punch. One feature was noticeable — a distinct radiusing of the edge at the point of final separation of blank from stock. All punchings exhibited this feature but it was not considered particularly detrimental. The stock was always left flat and undistorted, facilitating its further use, as was necessary in the case of some of the original work.

on press mechanically

The reduction in strain on the press was very apparent. Blanks with an Lm of 13 tons were regularly produced on a bench press of 6-ton rating with no sign of strain. The reduction in shock loading would certainly eliminate most of the maintenance troubles experienced with presses, and could lead to generally much lighter press construction.

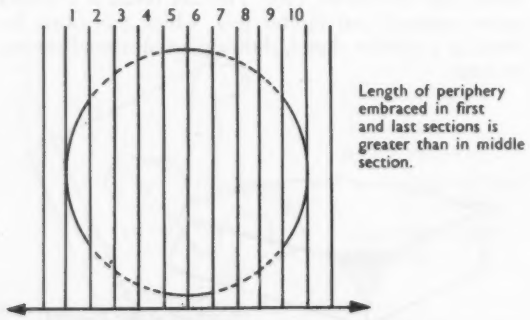


Fig. 16. GRATICULE SHOWING WHY CIRCULAR PUNCH SHOULD NOT BE USED FOR TESTS.

on power consumption

When using an unsheared punch the initial impact load absorbs a large amount of the kinetic energy of the flywheel, so reducing the speed. This in turn reduces the motor speed, frequently below the normal full load range. A sharp rise in motor current results, dropping only as the flywheel accelerates after the punching is complete. With a continuously sheared punch the torque loading of the motor never rises as high as with an unsheared punch, and usually speed can be maintained within normal limits with little rise in motor current. The net result is an overall reduction in current consumption. Limited tests support this, but it is not possible to say with any certainty to what extent.

on the operator

The reductions in noise and vibration make working conditions less tedious, and concentration becomes easier. Higher rates of production can be achieved, as "rest breaks" become shorter and less frequent.

conclusion

apparent advantages

The investigations and trials indicate that there are considerable advantages to be gained from a more general use of continuous shear on punches. Tooling costs are reduced; loading of presses is lowered enabling more extensive use of lighter machines with consequent reductions in capital expenditure and operating costs; material conservation is assisted by the non-distorting behaviour of these tools; and the overall reduction in noise and vibration has certain distinct psychological and physiological advantages.

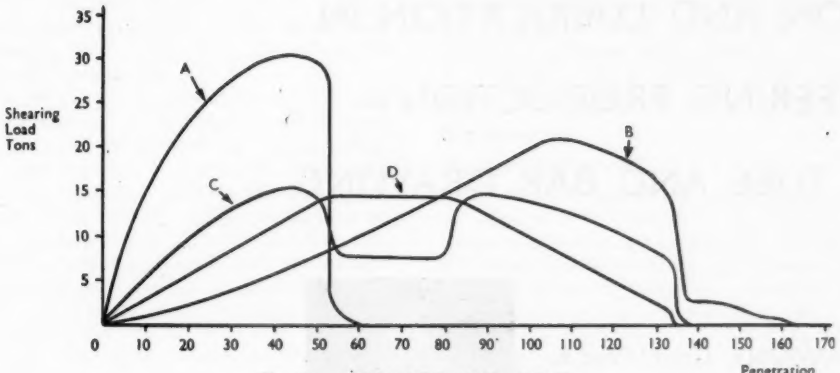


Fig. 17. COMPARATIVE LOAD CURVES

Material: O.080 in. Mild Steel.

Curve A Experimental curve 6 in. dia. tool, no shear.

Curve B Experimental curve 6 in. dia. tool, 0.064 in. double shear.

(Curves A & B according to Chang.)

Curve C Calculated curve. Square tool 4.7 in. side (i.e., same periphery as 6 in. dia. tool). Single shear 0.064 in. applied conventional manner.

Curve D Calculated curve. Square tool 4.7 in. side. Continuous Shear 0.064 in.

Relative values of work done:

Curve A = 100 **Curve B** = 125
Curve C = 115 **Curve D** = 100

further research required

It must be stressed that a great deal of further information is required before final facts and figures can be safely published. To produce this information investigation is necessary into the following :-

1. Relationship between work done when making a given length of cut in a piece of material of controlled composition and thickness when using unsheared guillotine blades, and with varying degrees of shear, covering also effect of blade clearance. Suggest extension of Chang & Swift's researches on "Shearing of Metal Bars" 9.
2. Behaviour of metal during cutting with sheared blades. This will entail micrographic examination of cross sections of partially completed sheared cuts in pieces of metal (Fig. 15).
3. Limiting angle of sheer to cut without bending. Required for a range of materials and thicknesses. Tabulate results using punches having varying angles and lengths of shear.
4. Penetration to effect complete severance of blank from stock. Tabulation of results using unsheared punches, in a range of sizes, on materials of varying composition and thickness.
5. Current consumption. Equipment for checking current consumption could be incorporated in the machines carrying out the other tests.

Finally, but probably most important of all :

6. Tests to confirm relationship between actual press loadings and those arrived at by calculation using the formula derived earlier in this Thesis.

All punches used in the above tests should be of square section. Circular punches do not give reliable results, because when single sheared they start and finish on a comparatively broad front. In all cases tests should be made on both metallic and non-metallic materials.

In view of the nature and extent of the foregoing researches, they would appear to be suitable for carrying out by the Production Engineering Research Association.

BIBLIOGRAPHY

1. "Pressworking and Presses." Grainger. 1952.
2. "Die Design and Diemaking Practice." F. D. Jones. 3rd Edition.
3. "Tool Engineers Handbook." A.S.T.E. 1st. Edition.
4. "Mechanical World Year Book." (Mechanical Presswork Section). Langton.
5. "Shearing of Metal Blanks." Chang. J.Inst.Metals. Vol. 78.
6. "Machinery's Handbook." 15th Edition.
7. "Pressworking of Metals." Hinman.
8. "Fundamentals of Presstool Design." Walker. 1954.
9. "Shearing of Metal Bars." Chang. J.Inst.Metals. Vol. 78.
10. "Shearing for Drop Forging." Billingham. Metal Treatment and Drop Forging. Oct. 1952.
11. "Blanking and Piercing Investigation into Punch Speed and Die Clearance." PERA Report No. 11.
12. "Blanking and Piercing." Part 2. PERA Report No. 22.
13. "Finish Blanking of Aluminium and Copper." PERA. Report No. 27.
14. "Punches and Dies." Stanley.
15. "Press Tool Practice." Houghton.
16. "Practical Die Design and Diemaking." Marshall.

FRICTION AND LUBRICATION IN ENGINEERING PRODUCTION — WIRE, TUBE AND BAR DRAWING

by J. S. HAWKINS, Grad.I.Prod.E.

THE factors affecting the high speed production of wire, drawn tube and bar, have been found to be similar for all three operations. The problems arising in wire drawing will be related and where differing problems in techniques occur, specific reference will be made to tube and bar drawing as is necessary.

history

Wire-drawing is a craft which has long been practised by man. Times and techniques have changed since the earliest days of wiremaking, when it involved cutting narrow strips from sheet; developing to more recent times with the use of a whortle plate. Wire-drawing has now developed into an operation requiring a high degree of precision and efficiency. Nevertheless, in spite of modern developments and drawing speeds in the region of 6,000 ft. per minute, the equipment used is relatively simple.

problems of wire drawing

(a) die wear

At the present time one of the most important remaining factors hampering production is the effect of die wear. Although very hard materials are employed for the die — tungsten carbide for the larger sizes and diamond for the smaller — die wear is considerable. Under typical industrial conditions, drawing copper through tungsten carbide dies, the increase in the bore diameter, due to wear, may be of the order of 10^{-5} in. per 10,000 ft. drawn. If the drawing speed is 6,000 ft. per minute and variations of diameter up to 10^{-3} in. are acceptable, after a period of about two-and-a-half hours of running the die must be changed. For materials other than copper the situation may be still worse.

(b) other factors

Other factors to be considered in the wire-drawing operation are: surface finish, reduction of drawing force, reduction of the number of anneals between draws, metallic transfer and the heating of the die.

(c) lubrication

A considerable amount of research has been devoted to the lubrication of the die in recent years, and by the use of a suitable form of lubrication the hampering effects of the above factors can be reduced to a certain extent.

(d) difficulty in obtaining certain information

It is regrettable, though quite understandable, that it is difficult to obtain information relating to some of the more specialised drawing techniques. Industries concerned with the manufacture of wire for needles and springs, for example, tend to shroud their techniques with a certain amount of secrecy.

frictional forces in wire-drawing

Extremely high pressures are experienced between the die and the wire. In view of these extreme pressures it is somewhat difficult to assess the behaviour of the lubricant, and to derive or obtain a suitable value for the co-efficient of friction between the die and the wire.

According to Dr. Tabor, one of the major difficulties in any theory concerning the friction in wire-drawing, is to have to assume that the co-efficient of friction between the wire and the die is a single value constant. The conditions in the lubricating film are extremely complex and the properties of the film might be greatly influenced by the high pressures which exist.

In a recent Paper to the Institution of Mechanical Engineers, J. G. Weistrech has revealed weaknesses in existing wire-drawing theories. His results are of interest; though those concerning the effects of friction are not yet conclusive.

He maintains that with a well-lubricated die and wire, the assumption of a constant co-efficient of friction was but a minor blemish of wire-drawing theory. He did not consider that a better agreement of results could be obtained with experiments from which all variations of friction, along the surface of contact, had somehow been eliminated. He also doubted whether a constant co-efficient of friction could be ensured by the method suggested by Dr. Tabor, whereby lubrication was provided by a thin film of soft metal. Due to the variation in shear stress with temperature change this form of lubrication would also entail varying frictional forces.

effect of μ on yield stress

Weistrech carried out tests to observe the effect of μ on yield stress. Annealed oxygen-free high conductivity copper wire was reduced 38% by drawing through a tungsten carbide die. In one experiment, the wire was thoroughly lubricated with soap. In the other, the wire was thoroughly degreased. The drawing force in the second experiment was more than double the first. In spite of this the yield stress was practically unchanged, the effect of μ being confined to the initial steep portion of stress strain curve.

friction and die pressure

Previous investigators found that the co-efficient of friction increased with die pressure. This is contrary to the results of Wiestrech's experiments.

However, the manner in which the die pressure was varied in each case gives rise to possible sources of error. Weistrech varied die pressure by varying the die geometry, whereas the previous investigators (Lueg and Treptow) and (Baron and Thompson) obtain the variation in their experiments by repeatedly drawing the wire. Perhaps more agreement in the results would be obtained if the variation in die pressure was brought about by means of back pull. (*Tables I and II.*)

The need for some form of lubrication of the die and metal surface was most important. In the following sections is given an analysis of some of the frictional problems encountered in the various stages of production, and the way in which endeavours have been made to overcome them.

hot drawing

drawing technique

In the production of drawn tubes, to which attention will be devoted in this section, the primary stage of manufacture is piercing the red hot billets. This operation is in effect one of extrusion. However, the lubrication methods are identical to those used in the next operation, which is the first drawing pass of the hot billet. The billet, or bloom as it is called, is still at red heat and a pass involving considerable reduction in area is made. It is only possible to make this large reduction because of the considerable plasticity of the metal due to its temperature. Hence the pressures between the die and the metal surface are no greater than in cold drawing operations.

lubrication requirements

The main problem in hot drawing lubrication is to find, not necessarily a high pressure lubricant, but one that will retain its lubricating properties in the region of 1500°F.

lubricants in use

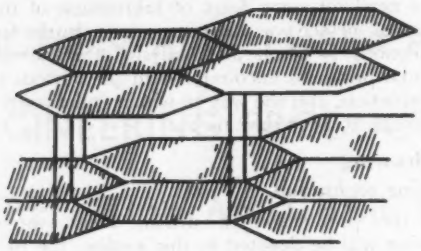
Graphite, in both colloidal and normal flake form, has been found to be the most suitable lubricant. Research has shown that other materials, such as glass powder, have a greater attraction as lubricants, but their application to the billet is still proving difficult.

Graphite is a good lubricant because of its laminated molecular structure (Fig. 1). The hexagonal layers slide over each other in the same way as a pack of cards would slide over each other when thrown on to a table. The graphite is placed on the surfaces in contact and fills in the layers between the rough surfaces (Fig. 2). Hence, sliding occurs between the layers of graphite and metallic contact is avoided.

Mr. Hawkins was educated at Rydal School, Colwyn Bay, and Loughborough College of Technology where, after studying Aeronautical Engineering, for a period, he became a Sandwich student in Production Engineering, in 1955. In 1958 he was awarded the Diploma of Loughborough College and took a 12 months' post-graduate Course in Industrial Management to gain the Associateship of the College.

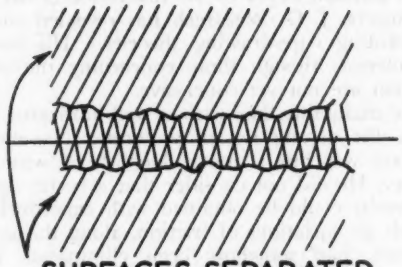
He has recently taken up an appointment as Personal Assistant to the Outside Erection Manager with Aiton & Company, Derby.

The Paper published here was presented to the Liverpool Section of the Institution of Production Engineers in January, 1959.



LAMINATED GRAPHITE STRUCTURE

Fig. 1.



SURFACES SEPARATED BY GRAPHITE INTERFACE.

Fig. 2.

TABLE I. EFFECT OF FRICTION ON DIE PRESSURE

Test No.	*Die Semi Angle*	*Reduction of Area*	*Coefficient of Friction*	*Die Pressure Tons/IN²*	
				Test (1)	*Test* (2)
(1) (2)	0.11	0.435	0.020 .009	17.9	19.9
(1) (2)	0.14	0.271	0.028 0.022	21.7	22.6
(1) (2)	0.17	0.369	0.031 0.024	19.3	19.9
(1) (2)	0.20	0.294	0.034 0.022	22.8	23.3
(1) (2)	0.23	0.456	0.038 0.008	19.0	20.0

Some of the results given above show extreme values for μ. These are not representative.

TABLE II

This Table gives the experimental values of μ, and also the frequency of their occurrence

FREQUENCY TABLE OF COEFFICIENTS								
Coefficient of Friction μ	*Mean Die Pressure — Tons/IN²*							
	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55
0.005-0.015	1	4	1	1	0	0	1	0
0.015-0.025	16	12	6	1	1	1	0	0
0.025-0.035	22	21	5	3	1	0	3	1
0.035-0.045	3	3	1	1	1	0	1	0
0.045-0.055	0	0	1	1	0	0	1	0

An indication of the value of graphite as a lubricant at high temperature is shown in Fig. 3.

It can be seen that the graphite is unaffected by heat up to 1000°F, and up to higher temperatures in reduced atmospheres. In actual fact, the co-efficient of friction of a graphite film has been observed to decrease with rise in temperature. This is probably due to a reduction in the forces of molecular adhesion, Van der Waals forces, weakening with rise of temperature.

Graphite is a dry powdery substance, and requires some "vehicle" substance with which it must be mixed, in order to make it adhere to the surface to be lubricated. When in the form of flaky graphite, tar is mixed with it, and in this way the combination can be used as a lubricant. The colloidal graphite may be mixed with water or, more suitably, some mineral spirit.

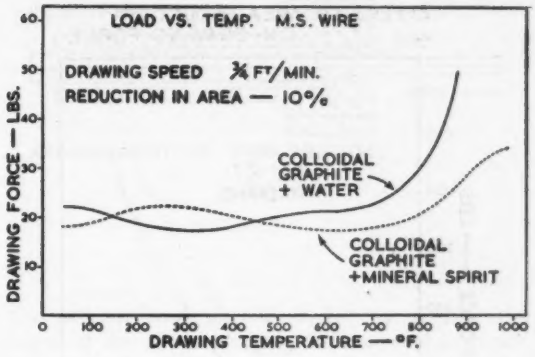


Fig. 3.

cold drawing

The study of lubrication in the cold drawing process is perhaps of greater importance than in the hot drawing. The latter is very rarely used as a finishing process and the lubricant is used to counteract die wear and large drawing forces. However, in cold drawing further problems arise because it is frequently a finishing operation. In addition to the problems previously encountered, in hot drawing, surface finish, metallic transfer, heating of the die and reducing the number of anneals between draws are factors which must here be given consideration.

die wear

Die wear can be considered the controlling factor in the production of wire. It is understandable then, that the greatest amount of time and money spent on research in this field is spent in an endeavour to find methods of increasing die life. An increase in die life of 1% is considered to be very worth while.

For most sizes of material the dies are made of tungsten carbide, though the smallest diameter wire is drawn through diamond dies. The hardness of a metallic die is governed by two factors. In the first case it is normally found that the harder the metal, the more brittle it becomes. This entails expense in the form of an elaborate reinforcing case for the die. This is virtually a limitation depending on materials available. The greater the hardness differential between the die and the metal surface, the greater is the danger of metallic transfer.

Having arrived at a suitable material for the die, wear on the die is minimised still further only by correct die geometry (which is usually governed by designing for reduced drawing forces), and correct lubrication.

In the past, lubrication has usually been in the form of either dry soap powder, or an aqueous solution of soft soap. In both cases it is a simple sodium stearate base compound. Mineral oils are rarely used.

In contemporary wire-drawing processes a sull coating is applied to the wire prior to lubrication. This coating is similar in function to the "vehicle" required for graphite in the hot drawing.

The following brief outline of the sull coating procedure may be taken as being general present day practice :-

1. 30 - 60 min. immersion pickle in cold HCl or H_2SO_4 solution, to remove scale.
2. Spray water rinse under pressure to remove acid and loose scale.
3. 1% HCl acid dip to initiate "rusting".
4. Sull coating. In the sull coating pit the coils are artificially "rusted" by spraying with fine jets of water. The requisite hydrated oxide coating is found in a period of about two hours. This coating provides the otherwise bare steel with a protective film in order that frictional resistance may be minimised.
5. Lime dip. In this operation the coils are dipped in a hot lime suspension to neutralise any trace of acid, to seal the hydrated iron oxide coating so that this will not degenerate to form an abrasive rust, and to facilitate drawing by later combination of the lime with the drawing lubricant.
6. Flash Baker. The coils are heated for 10 - 20 minutes in a gas oven, in order that the "rusting" process may be completely arrested.

After this somewhat lengthy process, the coils of sull coated wire are cold worked using dry soap lubrication.

This method takes considerable time and due to the complex mixture of the hydrated ferrous and ferric oxides forming the sull coating, it is difficult to bring about standardised optimum conditions.

A far more satisfactory method has been found, whereby the metallic surface is coated with a phosphate coating. This is known as the bonderising process and is later referred to more fully. Bonderising has a beneficial effect not only upon die life but on all other aspects of cold drawing.

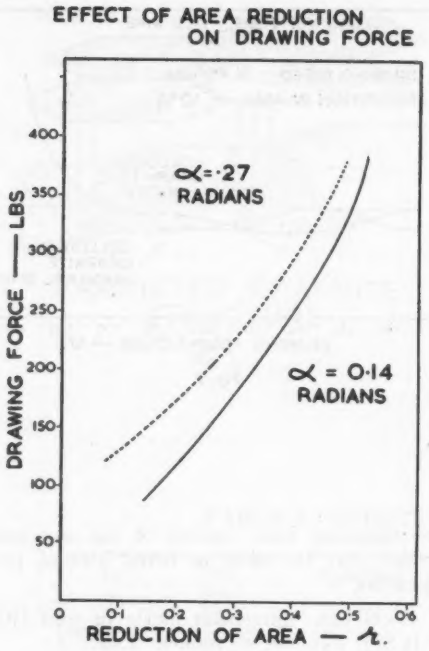


Fig. 4.

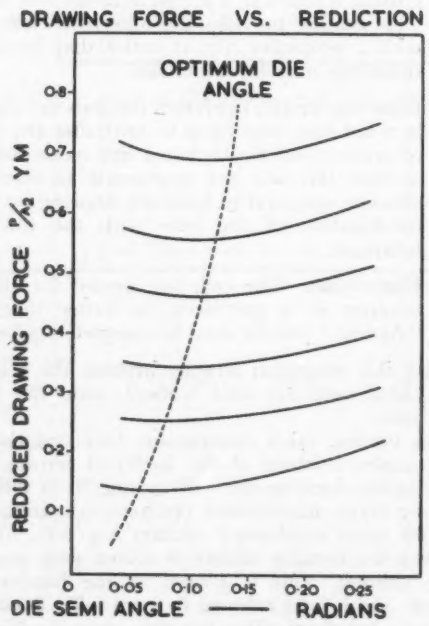


Fig. 6.

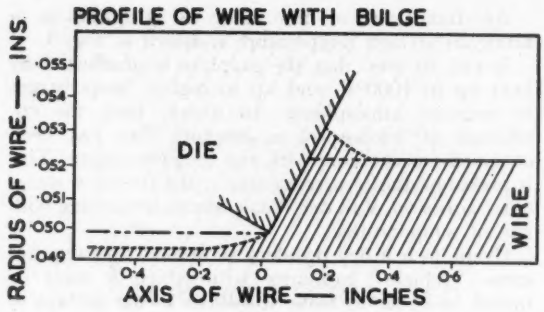


Fig. 5.

reduction of drawing force

In the general case of drawing round wire, the parameters affecting the external forces are four in number.

(a) reduction of area

The effects of reduction in area are shown by Fig. 4. The graphs are not linear. The fact that the curves do not pass through the origin is due perhaps to frictional drag, or more likely to the bulging of the wire before entry into the die (Fig. 5). It is interesting to observe the different deformation of the wire prior to entry into the die which occurs in the case of liquid lubrication (Fig. 6).

(b) die angle

The variation of drawing force with die angle is shown in Fig. 6. These curves show a definite minimum; a fact which is used to advantage in die design. The angle for which a drawing force is minimised for a particular reduction is given by :-

$$\text{Optimum} = 1.5\mu \log_e \left\{\frac{A1}{A2}\right\}$$

This theory cannot be applied to tube drawing, where corrections are required for mandrel geometry, etc.

(c) yield stress

(d) co-efficient of friction

The effects of friction in the drawing operations have been previously enumerated. With well lubricated wire the co-efficient of friction is well below $\mu = 0.1$. A slight increase in the μ value requires a considerable increase in drawing force.

It is of interest to note that Bowden and Tabor quote as a possible third law of friction: "Kinetic friction is nearly independent of the speed of sliding." Investigating at a later date Bowden carried out experiments concerning frictions at very high speeds. He found that at sliding speeds approaching 2,000 m.p.h. the frictional co-efficient had been reduced to 1/25th its value at low speeds. Although a high initial μ value, obtained by using oxide free surfaces, gives an optimistic reduction of friction, these tests are evidence of the invalidity of the suggested theory.

surface finish

Poor surface finish in the majority of cases is due to metal transfer, or pick up, to or from the die.

With insufficient or incorrect lubrication adhesion takes place and particles from the metal surfaces adhere to the die. Gradually these protruding particles become work hardened and scratch the wire surface.

Not only is it desirable to have a good surface finish because of the appearance of the product, but it is essential in cases where the product, be it wire, bar or tube, is to be subjected to any form of heat or mechanical stress. A surface scratch will form as a weakness when the product undergoes manipulation.

Scratching and pitting will make the surface more susceptible to corrosion. If pick up takes place from the die to the metal due to the different electrode potentials of the two metals in contact, corrosion will occur at the point of transfer.

There is one advantage of insufficient lubrication in connection with surface finish. The heat caused by friction is very great, but it is only present at local hot spots. When solids are rubbed together localised melting or high temperature softening takes place and the molten or softened metal is smeared over the surface, bridging and filling up the surface scratches It is quickly cooled to form an amorphous Beilby layer. This phenomenon is used to advantage in filament wire-drawing.

heating of die

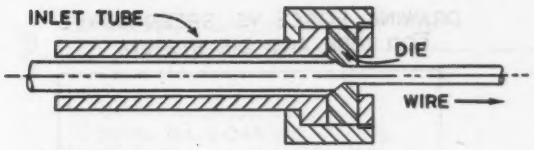
(a) fluid lubrication

A feature of particular importance in finishing operations is the sizing effect of the die. However, if the die is subjected to considerable increase of temperature the reduction in area per pass will be below the calculated value. A method of providing fluid lubrication of the die (put forward by Professor Christopherson and H. Naylor) has a valuable application in view of the cooling properties of this system of lubrication.

Under normal practice lubrication is of the boundary layer type, i.e., film a few molecules thick. Experiments have shown that it is not true boundary layer lubrication as is shown by the quantity of lubricant passed through the die, and also that the electrical resistance between the die and the wire is too great. This state is due to the presence of sufficient lubrication for fluid film type, but the absence of sufficient feed pressure to maintain the fluid film. To obtain true fluid film lubrication the oil feed pressure must be approximately equal to the yield stress of the wire. Hence values in the region of 25,000 lb./in^2 are to be expected.

(b) methods of providing fluid lubrication

This pressure is obtained by having a tube on the inlet side of the die (Fig. 7). The lubricant adheres to the wire and is drawn into the tube, being prevented from passing through the die because of the constriction. By this method the pressures increase with the increase of drawing speed. For varying drawing speeds the required pressure is obtained by altering the clearance between the die and the wire.



ARRANGEMENT OF TUBE AND DIE

Fig. 7.

The pressure may also be varied by altering the length of the tube and upon the choice of lubricant viscosity.

(c) analogy with journal bearing

Fig. 8 and Fig. 9 show the comparison between the frictional curve for a journal bearing and the similar curve for a die and tube drawing assembly. When fluid lubrication is present in both mechanisms they are frictionally similar.

In Fig. 8 at low speeds boundary layer conditions obtain. With an increase of speed an increasing proportion of the load is carried by fluid pressure. Minimum friction occurs at point B, where fluid lubrication is established. As the speed increases still further the drag of the fluid film increases disproportionately and an increase in friction occurs.

Fig. 9 is seen to be basically similar. The minimum B is much flatter than with the journal bearing. This is probably due to the sliding surfaces being relatively hard and not bearing metals.

It is probably desirable to run a bearing under conditions represented by point C. That is, to accept a higher value of friction in order to ensure that, even under a temporary chance overload, the lubricating film will not break down. Similarly it seems likely that the best operating conditions for the die are to be found on the right of the diagram.

FRICTION VS. SPEED FOR JOURNAL BEARING & DIE ASSEMBLY

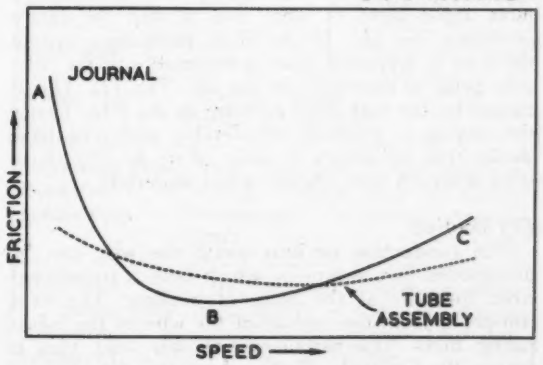


Fig. 8.

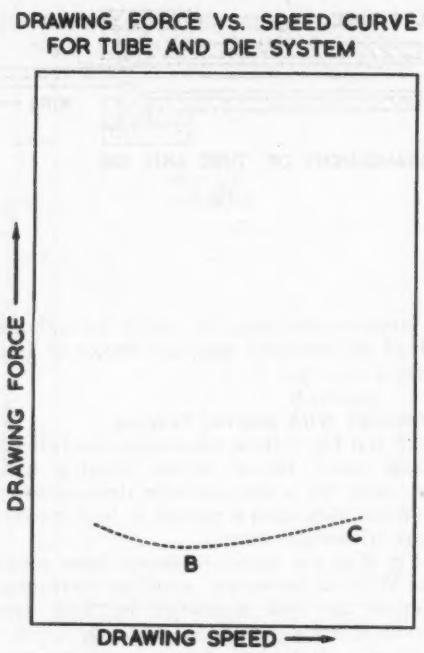


Fig. 9.

(d) direction of frictional forces

In certain instances when fluid flow is large, the net friction on the wire after leaving the tube is actually reversed, i.e., in a direction assisting the motion of the wire.

Under these conditions the pressure in the die is decreasing rapidly in the direction of motion, and the velocity distribution in the lubricant is as shown in Fig. 10. The lubricant layers near the wire surface are being forced out by the die pressure faster than the wire itself. Thus the viscous friction tends to drag the wire forward.

(e) reduction of ringing

The main element of die wear is ringing. This is the wear at the point corresponding to the original diameter of the wire. The ringing wear is usually the most rapid form of wear and is thus the factor governing die life. In the fluid lubrication system the wire is deformed quite considerably in the inlet tube prior to entering into the die (Fig. 11). This is caused by the high fluid pressure in the tube. Hence the ringing is reduced considerably and tests have shown that reductions in wear of up to 75% have been achieved with certain softer materials.

(f) cooling

The conduction of heat along the wire can be disregarded as a means by which heat is transferred from the wire at the point of working. The heat transfer is from the surface of the wire to the lubricating fluid. The turbulence of this fluid film is responsible for such effective heat transfer. This is particularly valid with high thermal conductivities.

bonderising

Many of the difficulties encountered in cold drawing metals have been overcome by providing the surface of the article with a thin crystalline coherent coating of metallic oxide or salt. The crystals of this oxide or salt are in a heterogeneous crystalline union with the metal base. Experiments have shown that phosphate or oxalate coatings are to be recommended.

crystalline behaviour under load

The phosphate coating not only acts as a carrier for lubricant, but takes part itself in the deformation without becoming detached and therefore acts as a further parting layer. In working processes the individual crystals shear, while the base of the crystals adhere to the surface.

formation

These coatings are formed by immersing the cleaned metal surface in a hot aqueous solution containing heavy metal primary phosphates, some free phosphoric acid and an accelerator, or catalyst. Tertiary zinc phosphate is formed ($Zn_3(PO_4)_2$ and H_2O) producing a laminated fragmented type of zinc. Due to the crystalline form of the phosphates, they form innumerable pores and capillaries which form the vehicle for the lubricant. This also ensures that the lubricant is uniformly distributed over the surface. There is a quantitative and qualitative increase of retention of lubricant, but the amount held only increases slightly with the thickness of the phosphate coating. Hence the absorption is due to surface phenomenon and with non-polar lubricants the process is purely mechanical.

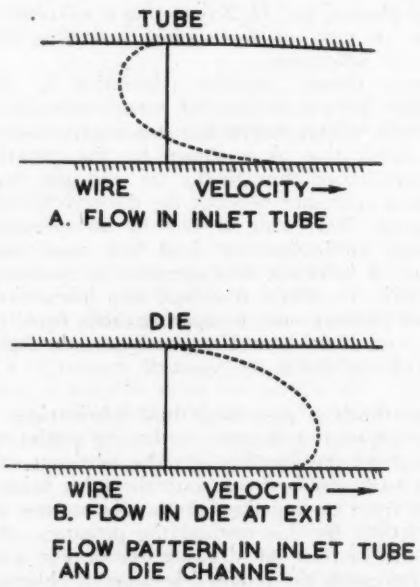


Fig. 10.

reaction with polar lubricants

When phosphate coatings are treated with polar lubricants chemical reactions occur, hydrophobic metallic soaps being formed. The soaps are precipitated on to the surface of the phosphate coating, to which they tightly adhere.

These water insoluble soaps are chemically non-reactive towards metallic surfaces, and behave as excellent lubricants under conditions of high pressure and temperature.

comparison with sull coating

The phosphate or bonderising process replaces the sull coating precedure, and industrially one of its great advantages over that system is the shorter time required for the preparation of the metallic surface.

A flow sheet for both processes adopted for the manufacture of steel tubes is given to demonstrate this :-

Initial Hot Drawn Material	
Annealed	
Acid Pickle	
Immersion	
Running Water Rinse	
Formation of Rust Draw Coat (Up to 5 hours)	Immersion Bonderising 5 - 10 min. 150 - 160°F
Lubricate	
Draw I	Hot Water Rinse
Anneal	
Acid Pickle	Lubricate
Water Rinse	Draw I
Formation of Rust (Up to 5 Hours)	Lubricate Draw II
Lubricate	
Draw II	

Further benefits of this type of lubrication are found to be: longer life of the drawing tools and dies, reduction in power requirements, a greater number of draws possible without inter-anneal, and the use of emulsions of low oil content in the place of high viscosity lubricants and soaps.

lubricants

The essential problems of lubrication in the drawing processes are more concerned with the manner in which the metallic surface can be made to retain its lubricating film, or in which way the lubricant can best be supplied to the die. However many lubricants (with varying properties) are in use.

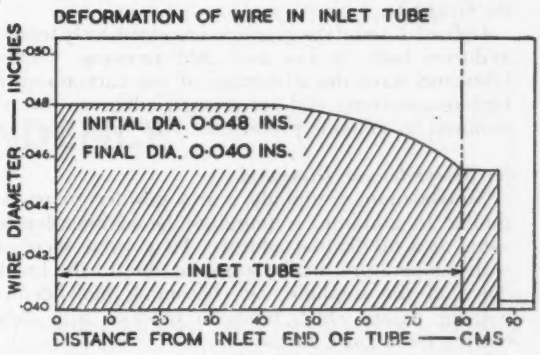


Fig. 11.

soap

Broadly speaking, it can be said that die lubrication takes the form of dry soap at low speeds and aqueous solutions of soap at higher speeds. It seems that the use of mineral oils is infrequent. However, the use of additives have improved the lubricating properties of these soaps.

additives

(a) *Sulphur and Chlorine*

The addition of sulphur improves the lubricating properties at high temperatures, though in the case of brass, if there is free sulphur in excess, it causes staining. When combined sulphur is present, i.e., more closely combined with the lubricating molecules, there is noticeably less effective lubrication. The addition of chlorine to the soaps improves frictional behaviour.

The Table below shows the performance of lubricants with various additives.

Main constituents	*Frictional behaviour*	*Practical performance*
Sodium Stereate	Average marked breakdown over 150°C.	Satisfactory under favourable conditions. Small safety margin.
Sulphurised Olein Caster Oil Ammonia Soap	Very good. Slight breakdown at 180°C.	Very satisfactory. Superior to soap. Staining.
Chlorinated Mixed Acids Sodium Soap	Very low friction up to 120°C. Marked break-down at 150°C.	Somewhat better than soap.
Sulphurised Olein Caster Oil Sodium Soap	Very good. Low friction. Slight breakdown at 200°C.	Extremely satisfactory. Far superior to soap. Staining.
Chlorinated Mixed Acids Sodium Soap Sulphurised Fatty Acids	Very low friction up to 200°C.	Extremely successful in drawing steels. Little staining.

(b) *Graphite*

Colloidal and flake graphite are extensively used as additives both in hot and cold drawing. These lubricants have the advantage of not carbonising at high temperatures and are strongly adherent and not removed by extreme pressures.

(c) *Molybdenum Disulphide*

Molybdenum disulphide, a grey powder, somewhat similar to graphite, is found to be of considerable value as a lubricating additive. Its μ value increases with temperature, unlike graphite, due to the breakdown of the sulphide, i.e., becoming molybdenum without oxide, which tends to produce a μ value correct for a pure metal.

lubrication of stainless steel

The lubrication of stainless steel for cold working differs from other metals mainly because of the higher die pressures involved, and also the difficulty in forming a "vehicle" coating. When the surface is bonderised an oxalate coating can be formed, rather than the phosphate coating found on other metals. Colloidal molybdenum disulphide with a volatile carrier has been applied to etched stainless steel and was found to be very satisfactory. However, a thin film of lead is industrially used and recommended.

Hot drawing of stainless steel involves great difficulties due to the unstable austenitic structure. Only in the stabilised form, i.e., with the addition of titanium or columbium, can it be safely hot drawn.

conclusions

In cold drawing processes, friction is a major problem. It is not so much the work done in overcoming friction — the power loss — though this is, of course, considerable; the real trouble is the damage that is done by friction, the wear on the vital parts of the mechanism.

In this Paper some of the generally accepted methods of reducing friction have been outlined, together with some theories which have been shown to be useful, but as yet are not in widespread use. Some suggestions put forward would be difficult to employ because of practical considerations. One of these is the coating of metallic surfaces with a fluid film of molten glass. Theoretical and laboratory tests have shown the advantages of this scheme, but it would necessitate storage tanks for the molten glass dip. These would require continual heating to prevent solidification, and the disastrous effects of a burst tank can be well imagined.

In this field of research, there is considerable co-operation between the scientist and the engineer. It will only be as a result of the close collaboration of the scientist and the production engineer that the problems with which they are faced will be overcome.

acknowledgments

The author is indebted to The Chesterfield Tube Co. and Messrs. Accles & Pollock for kindly allowing him to obtain first-hand information on the subject of tube drawing, and for their general helpfulness.

REFERENCES

Proceedings of The Institution of Mechanical Engineers:

"Promotion of Fluid Lubrication in Wire Drawing" by Professor Christopherson and H. Naylor.

"Investigation of the Mechanics of Wire Drawing" by J. G. Weistrech.

Chartered Mechanical Engineer:

"Recent Studies of Metallic Friction" by F. P. Bowdeth

"Friction and Lubrication of Solids" by Bowden and Tabor.

"Manufacture of Iron and Steels" by Brandt.

"British Wire Drawing and Wire Working Machinery" by H. Dunell.

"Wire, Its Manufacture and Uses" by J. Birchnall Smith.

"Application of Phosphate Coatings to Wire Tube and Bar Drawing" by H. A. Holden.

"Colloidal Graphite as a Wire Drawing Lubricant" by D. G. Weaver.

"Colloidal Graphite for Metal Working Operation." Acheson Colloids Ltd.

"Lubricating Graphite." Foliac Ltd.

"Bonderising for Wire Drawing." The Wire Industry.

"History and Development of Phosphate Coatings." Electrodepositors Technical Society.

References have been made from a liberal supply of technical literature kindly supplied by the following companies:

Pyrene Co. Ltd., London
Foliac Co. Ltd., London
Acheson Colloids Ltd., London
I.C.I. Ltd., Metal Finishing Division

CORRESPONDENCE

"A Report on Production Engineering in British Universities."

From : **Professor N. A. DUDLEY, M.I.Prod.E., Lucas Professor of Engineering Production, University of Birmingham.**

ALTHOUGH Mr. R. C. Brewer of Imperial College claims that his "Report on Production Engineering in the British Universities" — which appeared in the December, 1959, issue of the Journal — is "largely a factual presentation", he very rightly draws attention to differences of opinion on the nature of such studies. His comments, however, on the award of the M.Sc. degree for the post-graduate course in Engineering Production in the University of Birmingham are misleading.

It is asserted that it is a departure from the normal practice of awarding the M.Sc. as a research degree, but that this is "not so serious as the fact that a master's degree is awarded on the strength of only one year's study".

The facts are these :

The general practice with regard to the M.Sc. by research in English universities — other than Oxford and Cambridge — is that Honours graduates (sometimes only good Honours graduates) of the university in question can qualify in one year for the M.Sc., and other graduates can qualify in two years. Birmingham conforms with this general pattern, except that it appears to be in a minority in allowing Honours graduates of other universities on equal terms to its own — surely not an unreasonable practice.

The ordinances, or regulations, of several universities allow students to qualify for the M.Sc. by written examination or by written examination and dissertation. Furthermore, Birmingham University is not the only university which gives an M.Sc. degree on a 12-month course (including dissertation), as opposed to research — although most of the courses offered elsewhere seem to be in Pure Science rather than Applied Science. Since Birmingham University makes no formal distinction in Advanced work between Pure and Applied Science, this does not appear to be very important. At all events, it is incorrect to give the impression that it is quite abnormal to award an M.Sc. for an Advanced Course; rather it is a pattern of a fairly substantial minority. Incidentally, Engineering Production was Birmingham's first post-graduate course, although there are now 17 others in the Faculty of Science.

Mr. Brewer's further comments to the effect that Birmingham awards "what appears to be a superior qualification" for a course "not materially different" from a course or courses offered elsewhere cannot adequately be replied to in a letter. The post-graduate course in Engineering Production at Birmingham, now in its eleventh year, served a five-year "probationary" period before being raised to the status of an M.Sc. course. Several university Professors, including two at London, have acted as External Examiners, and have certified that our students' work has been worthy of the award of the M.Sc. degree. When the new post-graduate course in Operational Research was established in this Department last session, the University Senate, largely as a result of our past record, agreed that this also should lead to the award of the M.Sc. degree and, in fact, the first degrees — the first in the United Kingdom — have now been conferred.

It could have been noted that Birmingham has departed from normal practice in establishing an independent Department of Engineering Production and that Birmingham's progress in Engineering Production probably stems very largely from this fact.

Mr. BREWER replies :

IT is difficult to see how my remarks concerning the award of the M.Sc. degree at Birmingham University are misleading. I think it was clear to anyone reading the Report, where the factual presentation was coloured by personal comment.

The vagueness of Professor Dudley's letter makes it difficult to say how justified his case really is. It is agreed that most universities allow their own honours graduates to qualify in one year for the M.Sc. degree, but I would say that this is a minimum requirement based on the supposition that it is a research degree and that, in fact, few students get through their research work so quickly that it is an embarrassment to them. It is also agreed that most universities grant an M.Sc. in some subjects on a written examination only — London University does in some subjects, such as Mathematics — but how many universities grant an M.Sc. in Engineering, other than by dissertation or thesis ?

It is my own opinion that the American advanced study research type of Master's degree should have been adopted in this country many years ago but in addition to the conventional British M.Sc., and not as an alternative to it.

REPORT OF THE MEETING OF COUNCIL

28th January, 1960.

THE third Council Meeting of the 1959 - 60 Session was held on Thursday, 28th January, 1960, at 10 Chesterfield Street, Mayfair, London, W.1. The Chairman of Council, Mr. H. W. Bowen, O.B.E., presided over an attendance of 26 members.

Before proceeding with the business of the Meeting, the Chairman welcomed Mr. J. Cox, Honorary Secretary, North Midlands Region, and Mr. A. B. Brook, Honorary Secretary of the Eastern Region, together with Mr. F. W. Cooper, the Institution's Education and Technical Officer, who had just returned from a visit to India with Sir Walter Puckey.

Nomination of President and Vice-President

The Chairman said it gave him very great pleasure to nominate Mr. G. Ronald Pryor, the reigning President of the Institution, to continue in that capacity for a further year. It was difficult to find adequate words in which to express the debt which they owed to Mr. Pryor; his work for the Institution was beyond praise.

The proposition was carried unanimously, with acclamation.

The President thanked the Chairman of Council for his all-too-generous remarks, and members of the Council for the way in which they had received them. He would continue to the best of his ability to serve the Institution in the coming year.

It was with very great pleasure, in turn, that he nominated Mr. Harold Burke for the office of Vice-President. Mr. Burke was well-known to members, and had worked for the Institution for a great many years. They owed him a great debt of gratitude for the way in which he had carried through the Burke Report, which marked a turning point in the history of the Institution. The Institution could not have a better man to occupy the position of Vice-President.

The proposition was carried unanimously, with acclamation.

The Vice-President thanked members of the Council for their renewal of confidence in him, and said he would continue to do his best to serve the Institution.

Region and Section Quarterly Report Policy

The Council discussed this item at some length. It was finally agreed that the Chairman should write to all Regions and Sections requesting their co-operation in submitting Quarterly Reports, and suggesting that the item, "Quarterly Report to Council", should be made a standing item on Committee Agenda, to serve as a reminder.

Council Elections — Voting Procedure

It was reported that the Finance and General Purposes Committee had considered the suggestion that the elector should not be compelled to vote for a full list of candidates, but only for those he wished to see elected. The Council adopted the Committee's recommendation that no change be made in the present procedure.

Finance

The Council adopted the report on the Institution's finances, together with the Income and Expenditure account for the period July - December, 1959.

Schofield Travel Scholarships

The Awards Sub-Committee reported, through the Finance and General Purposes Committee, that the candidates for this year's Scholarships had not reached the standard required, and therefore no Award would be made. The Sub-Committee were now considering ways in which to give more effective publicity to this valuable Award, and to increase both the number and quality of the candidates.

Education

It was reported by the Education Committee that their main work during the quarter had been the consideration of courses of Universities and Technical Colleges in connection with the Associate Membership examination. In the period under review 31 courses had been examined.

The attention of Council was referred to the comprehensive survey by Mr. R. C. Brewer, of Imperial College, of production engineering work being carried out on Universities. (This report appeared in the December, 1959 Journal.)

Professor N. A. Dudley, of the University of Birmingham, said he did not agree with a number of statements in Mr. Brewer's report, and had prepared a letter regarding it for publication in the Journal. He suggested that on future occasions of this sort, a group representing all the universities should be charged with preparing it.

It was agreed that the Education Committee should discuss the matter with the Editorial Committee, and report back to the Council.

Membership

The Membership Committee reported that a rotating Panel of eight members had been set up to deal with applications for membership and transfer, the main Membership Committee now meeting only quarterly to consider matters of policy.

The Committee were at present reviewing the marking scheme and procedure adopted in respect of Theses, and the Notes for the Guidance of Candidates were being redrafted in order that the standard of Theses could be raised.

The Council approved a number of applications for membership and transfer, details of which appear on pages 240 - 241.

The Journal

The Council adopted the Finance and General Purposes Committee's recommendation that the Institution Seal be affixed to the new Journal Printing Contract between the Institution and Maxwell, Love & Co. Ltd.

The Editorial Committee were pleased to report that they were now in a position wherein the Journal Contents could be planned for a month or two ahead. This, combined with the improved supply of Papers dealing with production engineering research, had provided the Committee with an opportunity of considering the next phase of their policy discussions, which was concerned with the possibility of the separate presentation of certain Papers.

Satisfaction was expressed by the Council on the publication of the Journal in its new form, as "The Production Engineer".

Institution Papers

1959 Sir Alfred Herbert Paper

It was reported by the Papers Committee that the meeting held on 10th December, 1959, at the Royal Institution, London, when the 1959 Sir Alfred Herbert Paper was presented by Dr. D. F. Galloway, Director of PERA, was one of the most successful ever held. Dr. Galloway's subject, "Production Engineering Developments in the Soviet Union", attracted a capacity audience, in addition to which some 300 applications for tickets had to be disappointed. The President of the Institution was in the Chair.

1959 Viscount Nuffield Paper

Arrangements were well advanced for the presentation of the 1959 Viscount Nuffield Paper in Glasgow, on 17th March, 1960, when Dr. C. Timms, M.I.Prod.E., of the National Engineering Laboratories, was to speak on "Recent Developments in Spur and Helical Gears".

1959 George Bray Memorial Lecture

Arrangements were also in hand for the 1959 George Bray Memorial Lecture on "Packaging of Engineering Products" by Mr. C. H. Bulmer, of the Printing and Allied Trades Research Association.

1960 Viscount Nuffield Paper

The Committee were also pleased to report that Sir Stanley Rawson had accepted the Institution's invitation to present the 1960 Viscount Nuffield Paper at the Summer Meeting in London on 27th June.

Institution Medal Awards

The Sub-Committee appointed to assess Papers eligible for the 1958 - 59 Awards had now started work.

Conference Organising Committee

It was reported that the Conference had held three meetings during the quarter, and were making good progress in planning the programmes for the Symposium on "Machine Tool Control Systems," at Cranfield, in August and the Conference on "Modern Trends in the Manipulation of Metals" at Brighton, in October, 1960.

Members were being kept informed of developments through announcements in the Journal Supplement.

Research

The following reports were received from the Research and Technical Committee on behalf of their Sub-Committees:

Materials Handling Group

The Group Committee had continued its activity on the national project "Handling of Springs", and had also suggested that the subject of "Handling of Long Lengths" might be used as a subject for a one-day Convention.

The Study Group with the Building Research Station on "Co-ordination between the Production Engineer and the Building Designer" had completed its work and the information obtained is to be published as one of a series of booklets produced by the Building Research Station.

No further meetings had been held of the National Joint Committee on Materials Handling, but additional Study Groups had been set up, including one on Road Transport and Materials Handling, and another on Warehouse Construction.

Through the Joint Research and Technical Committee with the I.C.W.A., a Study Group was being set up on the subject on "The Costing of Materials Handling".

Computers and Production Control

The Sub-Committee's work on the proposed report was progressing.

Control of Quality

It was envisaged that the first meeting of the new Committee would take place early in 1960.

Co-ordination of Production Management Techniques

Steady progress was being made with this report, and the possibility of publishing an interim report was being considered.

Materials Utilisation

The Sub-Committee's report on "Improved Materials Utilisation" had now been published, and copies were available from the Institution's Publications Department.

Standardisation

It was reported that the Sub-Committee on International Standardisation continued to read and prepare comments on the implementation of I.S.O. recommendations and in particular, was currently working on the Institution's possible adoption of International Paper Sizes and the possibility of the production of a document covering recording and publishing Raw Materials Standards, particularly in the international field.

The Standards Committee continued to nominate representatives to B.S.I. Technical Committees.

The Joint I.Prod.E./B.S.I. Standing Advisory Committee on the use of Standards in Industry had discussed the proposed inception of a Standards Society, under the auspices of the B.S.I. They had also sponsored a new publication: "The Operation of a Company Standards Department", which had been very well received by industry.

The Library

For the Library Committee, it was reported that further discussion had taken place on the preparation of a history of production engineering. It had been concluded that the writing of such a history would be a tremendous task, and that the easiest way to perform it would be to divide the subject into its components, each of which would be treated in separate chronological sequence. It had been agreed to deal first with metalworking processes, this being an easily limitable subject and one with which the Institution was intimately associated. Great care must be taken to emphasise the practical industrial applications of the process rather than pure scientific bases, and this could more easily be done if the study were confined to the manufacture of a specific product or products. The product must be one in the manufacture of which varied and typical processes are used, and it was therefore decided that the small electric motor was such a product. Work had now begun on this project.

Region and Section Quarterly Reports

The Council received a number of Reports from Regions and Sections.

Liaison with Sections outside the United Kingdom

The Vice-Chairman of Council, Mr. R. H. S. Turner, reported that there had been no visitors to Headquarters during the past three months, but a considerable volume of correspondence had been handled, mostly concerned with the Secretary's tour and the question of subscription rates.

From the general report published in the Council Papers, it was obvious that the Councils and Sections overseas had been working satisfactorily, and had produced some excellent programmes.

On the question of subscription rates, several letters had been received acknowledging the Council's communication on the subject, and the proposals contained in the report were being carefully considered by local Sections and Councils overseas, and would be discussed with the Secretary during the course of his tour.

After the comments had been received, and particularly the Secretary's observations, the matter would be given further consideration by the Finance and General Purposes Committee, and would be brought up again before the Council.

Mr. Woodford's tour was well under way, and at the time of the Council meeting he was in Bombay. During his tour he would be visiting educational establishments and factories, and as the Institution's ambassador would be doing a great deal to improve liaison and co-operation with Sections outside the United Kingdom, and to cement the strong bond of friendship which already existed.

At the Chairman's invitation, Mr. F. W. Cooper, the Institution's Education and Technical Officer, gave the Council a brief report of his visit to India with Sir Walter Puckey. (A report of this visit appeared in the March issue of "The Production Engineer".)

Report of the Ad Hoc Committee on Organisation

At the invitation of the Chairman, Mr. R. H. S. Turner, Vice-Chairman of Council and Chairman of the Ad Hoc Committee on Organisation, presented his Committee's report. Copies had previously been circulated to members of the Council, together with the comments and criticisms received from Regions, Sections and Standing Committees.

The Report was discussed at some length, and was finally adopted by the Council, with the amendment that each Standing Committee should be free to choose the time and place of its meeting.

The Vice-President, Mr. Harold Burke, moved a hearty vote of thanks to Mr. Turner and his Committee for the valuable work they had done. They had added a new look to the work of the Institution over the last six years, and much gratitude was owed to them accordingly.

The vote of thanks was carried by acclamation.

Honours

The Council recorded with pleasure that the following members had been honoured by Her Majesty the Queen:

C.B.E.

Mr. Samuel Green, Member.

O.B.E.

Mr. Harry Bowley, Member.

M.B.E.

Mr. A. G. W. Cannon, Associate Member.

Obituary

The Council learned with deep regret of the deaths of the following members:-

Members:

T. P. N. Burgess; R. J. Cowey; W. H. S. Hodges; Lt.-Col. Leslie James Walker, O.B.E.

Associate Members:

G. Burton; C. A. Currier; A. J. Milburn; O. G. Parry; K. W. Tatchell.

Date and Place of Next Meeting

It was agreed that the next meeting of Council should take place on Thursday, 28th April, 1960, at 11 a.m., at 10 Chesterfield Street, Mayfair, London, W.1.

COUNCIL ELECTIONS, 1960-1961

A NOTICE calling for nominations to fill nine vacancies on Council, for the year commencing 1st July, 1960, will be published in May.

The vacancies will be for eight Members and one Associate Member. All Members and Associate Members of the Institution are eligible for election. Before nominating candidates for election their consent must be obtained.

Candidates for election must be nominated in writing by three Corporate Members of the Institution (Corporate Members: Honorary Members, Members and Associate Members). In addition, each Section Committee may nominate *one* candidate.

BINDERS FOR "THE PRODUCTION ENGINEER"

As a result of requests from members, the Institution is now able to supply the "Easibind" type of binder, in which metal rods and wires hold the issues in place, and which is designed to hold six issues.

It will be found that copies of "The Production Engineer" can be quickly and simply inserted into this binder, without damage to the pages, and that binding six issues at a time, instead of twelve, will facilitate easier reference and handling of the volumes.

The new binders may be obtained from: The Publications Department, 10 Chesterfield Street, Mayfair, London, W.1, price 10/6 each, including postage. Date transfers, for application to the spine of the binder, can be supplied if required, price 6d. each.

ELECTIONS AND TRANSFERS

28th January, 1960,

BIRMINGHAM SECTION

As Associate Members
L. Cox; R. M. Harrower; R. A. Floyd; N. P. Watts; W. C. Earl; K. G. Brown.
As Associate
J. B. Law.
As Graduates
A. C. Palmer; D. V. Bosley; C. Bennett; K. Baker; C. F. Stormont; D. G. Maisey; S. Norton; J. A. Hudson; A. Skudder; M. E. Glew; K. Pritchard; C. J. Tate; P. Wild; J. W. Clark; P. U. B. Hickin; A. S. Parr; J. H. F. Sawyer; C. Faulkner; A. E. Lorton; J. R. Thomas; J. E. Wylde; J. H. F. Wadsworth; J. F. Arrowsmith; W. H. Bentley; J. M. White; Miss M. G. Burley.
As Students
M. L. Turner; B. R. Cope; W. K. Luk; B. G. Cousins; S. J. Matthews.
Transfers :
From Graduates to Associate Members
E. E. Read; F. J. Silvester; D. R. Haywood.
From Students to Graduates
I. F. Campbell; H. J. Pedley; N. M. Crane; C. F. Bassford; C. Rone-Clarke; J. T. Downing; P. B. Sargent; Z. L. Rudnicki.

BOMBAY SECTION

As Associate
M. S. Srinivasan.
As Graduates
P. M. Somasekhara Rao; B. A. Patel.
Transfer :
From Graduate to Associate Member
T. Mathew.

CALCUTTA SECTION

As Graduates
K. K. Chatterjee; P. R. Sarkar; D. K. Gupta; A. Chattopadhya.
Transfer :
From Graduate to Associate Member
B. Nagchaudhuri.

CANADA SECTION

As Graduate
K. Hailstone.
Transfers :
From Graduate to Associate Member
F. R. Taylor.
From Student to Graduate
A. V. Pope.

CARDIFF SECTION

As Associate Members
A. V. Williams; I. Jones.
As Graduates
G. J. Wise; G. Powell; B. R. Field; R. J. Hannis; D. Keen.
As Students
R. E. Bale; L. J. Gambetta; D. Evans; K. G. Bull; A. R. Evans; W. A. Mannion; D. O. Phillips; R. M. Edmunds.
Transfers :
From Associate Member to Member
H. Probyn.
From Students to Graduates
P. R. Rogers; J. J. Roberts.

COVENTRY SECTION

As Member
A. N. Harley.
As Associate Members
S. L. Carvell; I. L. Robinson.
As Associate
W. R. Hunt.
As Graduates
G. A. Sparrow; J. H. Carter; A. Rice; K. W. Jones; B. J. Dennis; T. P. Taylor; R. J. Parkes.
As Students
W. Jobson; D. G. Parkes; H. Wagstaff; R. A. Fairhurst; K. T. Law; B. R. Lewis; J. S. Robinson; H. C. Harris.
Transfers :
From Students to Graduates
C. A. Windsor; M. Stokes; J. G. Carpenter.

DERBY SECTION

As Member
W. Colley.
As Associate Member
C. E. Linney.
As Graduates
K. M. Peerless; B. Stone; J. M. Birks; W. E. Leftwich; D. C. Kirk; D. C. Young; R. A. Bull; G. D. Crackle.
As Students
R. J. McNeilly; J. F. Mannell; D. J. Gent; M. F. J. Jarville; J. B. Waddoups.

DONCASTER SECTION

As Associate Member
I. M. Simpson.
As Student
B. Fawcett.

DUNDEE SECTION

As Associate Member
J. W. Tough.
As Graduates
J. N. Lees; H. J. Barrett.
As Student
C. M. Lockhart.
Transfers :
From Graduate to Associate Member
R. T. M. Doughty.
From Students to Graduates
A. Coleman; T. K. Burt.

EDINBURGH SECTION

As Associate Member
D. E. L. Simpson.
As Graduate
J. W. Young.

GLASGOW SECTION

As Associate Members
J. Wilson; H. Bentley.
As Graduates
T. M. Super; J. O'Hagan; I. B. Henderson.
As Students
J. Keenan; A. H. Neil; A. Bhattacharyya; J. Oliver; M. Spencer; I. M. Miller; J. Miller; A. M. Blair.
Transfers :
From Graduates to Associate Members
D. L. McIntosh; D. McPhail; D. S. Brown; J. Hall; J. S. Campbell; W. Hutchison.
From Students to Graduates
G. McCann; W. McLinton.

GLOUCESTER SECTION

As Graduates
N. R. Sabin; G. R. Cave; D. B. Radford.
As Student
K. Wright.
Transfers :
From Graduates to Associate Members
B. E. G. Clarke; T. J. Sullivan.
From Students to Graduates
C. T. Woods; P. J. Pratley.

HALIFAX SECTION

As Member
J. L. Brook.
As Graduate
D. B. Verity.

IPSWICH SECTION

As Member
G. J. P. Kerswell.
As Associate Member
A. J. Abbott.
As Students
A. N. Senanayake; J. H. Cole.
Transfer :
From Student to Graduate
M. J. Harden.

LEEDS SECTION

As Member
C. L. Whitaker.
As Associate Member
N. Brown.
As Graduates
K. Robinson; R. M. Wilkinson; H. Wood. W. H. Slingsby; W. Scholey.
Transfers :
From Graduates to Associate Members
T. Robinson; A. Salt.
From Students to Graduates
D. Brook; W. Hargreaves.

LEICESTER SECTION

As Graduates
P. Upton; J. P. Agarwal; Q. A. Shamsy; E. A. Oldham; D. A. Bell; A. J. Hudson; H. J. Causton.
As Students
A. A. Allen; A. S. Meyer; B. V. Hubbard; M. J. Cousins; J. A. Hizzey.
Transfers :
From Graduate to Associate Member
J. A. Stovin.
From Students to Graduates
E. H. Hanley; M. E. Partridge.

LINCOLN SECTION

As Associate
B. A. Coltman.
As Graduates
M. A. Hutson; D. R. White.

LIVERPOOL SECTION

As Graduates
H. Moore; J. H. Wells; K. G. Hughes.
As Students
K. M. Faraday; A. G. Bland.
Transfers :
From Students to Graduates
D. G. Griffiths; R. Roberts; A. G. French.

LONDON SECTION

As Associate Members
E. Simmons; J. F. Hedges; B. H. Lawson; E. A. Mauskopf; W. Bevan; W. T. Shelton; W. L. Gentle; C. G. Guess; R. F. Laurence; K. W. R. French; M. I. Qureshi; R. Bristow; L. F. Collett; R. J. Alexander.
As Associates
R. D. Pearsall; D. A. Luff; L. E. S. Watson.
As Graduates
K. H. Beecham; J. F. Churchman; M. Allen; W. Barnett; J. L. Callow; J. R. Oakley; D. W. Buck; A. R. Gilliver; C. H. Jemmett; R. W. Bannister; D. J. Bell; D. A. Watson; P. Barrand; R. L. Goldsmith; K. R. Elmer; R. Iredale; R. W. Dean; D. W. Hall; L. Deacon.
As Students
A. J. Filby; D. C. Hunt; C. C. Sinclair; M. Scarlett; C. D. Rawlins; R. L. Roberts; K. C. Hulford; M. N. Malhotra; A. H. Ross; J. A. Squirrell; W. E. Bryant; R. J. Baker; R. S. Cosford; G. A. Sanford; J. E. Rutter; J. V. F. Lindquist; G. Anson; D. Spurgeon; M. J. Lucas; C. Levi.

Transfers :
From Associate Members to Members
G. S. Brosan; A. R. Houseman; W. O. Bell; G. Jenkins.
From Graduates to Associate Members
N. J. Rippingham; R. Morris; R. H. Bailey; J. D. Rogan; T. R. Russell; F. A. J. Clover; I. B. King; N. J. Bullock.
From Students to Graduates
J. N. Warren; R. J. Vaughan; J. E. Rogers; D. Brewer; P. H. S. Edwards; J. R. Smith; A. A. Shumsheruddin; T. R. Lawrence; H. R. Knight; B. G. Pizzey; F. J. Egenolf; D. M. Fisher; T. A. Hollobone; J. A. Neate; B. L. Bowbrick; P. J. Convert; N. G. Hine; G. M. Webb.

LUTON SECTION

As Member
W. A. Train.
As Associate Members
D. F. Munro; D. Currie; J. R. Gilbert.
As Graduates
R. B. Barrington; D. J. Meade; H. J. Hay; R. V. C. Butters; D. A. Skeens; R. J. Hart; J. P. G. Goldfinger; P. R. B. Charles; J. Helps; P. R. Batchelor.
As Students
N. G. Fletcher; P. W. Shipton; L. Staples; D. V. Poole; B. C. Davies; D. F. Lake; N. L. Gurney; M. W. Shepherd.
Transfers :
From Associate Member to Member
C. C. Williams.
From Graduates to Associate Members
E. G. Sparkes; R. P. Brackenbury; J. R. Burton.
From Students to Graduates
F. W. Kenzie; A. C. Swain; P. D. Nevard; P. J. Coles; J. M. O'Grady; J. M. Aubrey; J. B. Guttridge; R. S. Sutcliffe.

MANCHESTER SECTION

As Associate Members
L. G. Ablett; A. T. Stewart; T. Jones; J. Lyon.
As Graduates
A. G. Callimachos; K. L. Malik; H. Guy; K. Bell; R. Fletcher.
As Students
L. Warren; B. M. Rensler; J. T. Benson; R. Chandra; T. J. McDonagh; N. Rose; R. K. Mason.
Transfers :
From Graduates to Associate Members
E. Page; R. K. Stephenson.
From Students to Graduates
T. A. Bainbridge; H. W. Ratcliffe; B. J. Tweats.

MELBOURNE SECTION

As Member
W. McP. Eady.
As Graduate
A. H. Sheldon
Transfers :
From Graduates to Associate Members
F. T. Purse; H. B. Davies.

NEWCASTLE UPON TYNE SECTION

As Associate Member
J. R. Alder.
As Graduates
J. E. Pigdon; M. G. Whiston; K. Henderson
As Students
R. J. Carr; J. P. Jeffery; D. G. Oswald.
Transfer :
From Graduate to Associate Member
W. Hayes.

NORTHERN IRELAND SECTION

As Associate Members
F. T. Wilson; L. Q. Hawe.
As Graduate
P. J. Peters.
Transfer :
From Associate Member to Member
F. Ralphson.

NOTTINGHAM SECTION

As Associate Member
W. B. Heginbotham.
As Associate
K. A. Critchley.
Transfer :
From Student to Graduate
R. Walker.

OXFORD SECTION

Transfer :
From Graduate to Associate Member
M. Haslehurst.

PETERBOROUGH SECTION

As Graduates
R. Zahawi; J. Little.
As Students
V. K. Sondhi; G. F. C. Carter.
Transfers :
From Associate Member to Member
L. B. Oldfield.
From Student to Graduate
E. A. Warman.

PRESTON SECTION

As Associate Members
R. W. Dyke; A. Kennedy.
As Graduates
J. T. Robinson; A. Rawstron; J. Astin; F. K. Thom.
As Students
E. T. Whitehead; C. Howarth; D. H. Rigby; J. R. Brimelow.
Transfers :
From Graduates to Associate Members
P. T. Hughes; K. Walmsley.
From Students to Graduates
B. D. Britton; B. Mawdsley; A. S. Smith; R. P. Sinclair.

READING SECTION

As Member
C. H. Langer.
As Graduates
R. Tomlinson; M. Lock; R. Philpot
As Student
J. E. Graham.
Transfer :
From Graduate to Associate Member
E. R. Landon.

ROCHESTER SECTION

As Graduate
B. R. Lawrence.
As Students
E. J. Brunger; V. H. Finnis; P. D. Clayton; S. R. Croucher; D. E. Bleckett.
Transfers :
From Students to Graduates
J. W. Goodhand; A. J. Clark.

SHEFFIELD SECTION

As Member
W. F. G. Kerley.
As Graduates
J. Cartwright; J. V. Flynn.
As Student
R. F. Hughes.
Transfers :
From Graduate to Associate Member
G. C. Sharp.
From Student to Graduate
F. K. Webster.

SHREWSBURY SECTION

As Associate Member
C. H. Podmore.
As Associate
N. D. Cutting.
As Graduate
L. D. Wright.
As Student
C. J. Davies.
Transfer :
From Graduate to Associate Member
G. Yates.

SOUTHAMPTON SECTION

As Associate Member
E. A. Turner.
As Graduates
D. J. Halliday; D. C. Wilson; K. Hobbs; B. K. Balhetchet; P. J. S. Mitchell.
As Students
L. R. Lewin; A. Morton.
Transfers :
From Graduates to Associate Members
W. J. Botting; R. J. Hailes.
From Student to Graduate
J. L. Dillon.

SOUTH AFRICA SECTION

As Associate Members
R. D. Baines; T. K. Purdon; G. F. Pettet.
As Associate
J. C. Jenkins.

SOUTH ESSEX SECTION

As Associate Members
L. A. Cox; P. J. Carter.
As Graduates
A. W. Mower; P. T. Massey; J. B. Morris; B. S. Champness; D. G. K. Abernethy; L. C. May.
As Students
E. J. Rayment; R. V. Francis; D. Farmer; D. E. Carter; P. J. Worthing.
Transfers :
From Graduates to Associate Members
G. E. Wright; B. J. Andrews.
From Students to Graduates
R. P. Knowles; L. A. Whiting.

SOUTH WALES SECTION

As Graduates
K. Jones; A. V. N. Powell.
Transfers :
From Graduates to Associate Members
D. F. Perry; D. S. Dugdale.

STOKE-ON-TRENT SECTION

As Graduates
W. G. Ellis; J. A. Cooper; J. M. A. Todd; K. Johnson.
As Students
T. Gilbert; T. J. Martin; R. A. Bolton; M. J. Warrington.
Transfers :
From Graduate to Associate Member
D. R. Smith.
From Student to Graduate
M. H. Smith.

SYDNEY SECTION

As Associate Member
J. F. Wales.

TEES-SIDE SECTION

As Associate Member
R. Thornton.
As Graduates
J. A. Roddy; A. Coates.

WESTERN SECTION

As Associate Member
I. H. J. Bennett.
As Graduates
P. Mott; F. E. Farrell; P. G. H. Brown; R. V. Moore; M. D. Francis; R. D. Brooks; A. C. D. Cumming.
As Students
M. H. Phillips; B. T. Watts; R. A. Billett; P. M. Holley; W. J. Crowson.
Transfer :
From Graduate to Associate Member
C. R. Blake.

WOLVERHAMPTON SECTION

As Associate
R. E. Soanes.
As Graduates
D. A. Mountney; D. Parkes; T. V. N. Tuft; R. Horden; M. E. Purslow; E. L. Burdett; W. M. Nash; K. S. Southall; T. C. Brown; R. J. Springthorpe; H. C. Webb; M. J. Morgan.
Transfers :
From Graduates to Associate Members
G. W. Adams; T. J. Harrison; O. J. Jones; W. P. Mirtle; K. V. Barber; D. Lardge.
From Students to Graduates
I. H. Cotton; W. J. Heap.

WORCESTER SECTION

As Associate Member
K. H. Tomlinson
As Students
N. O. Rose; R. H. Hodge; P. A. Bridges.
Transfers :
From Graduate to Associate Member
J. D Langford.
From Student to Graduate
R. Kettaneh.

NO SECTION

As Associate Member
R. A. Aitken-Holt.
As Graduates
S. M. Soto; M. Bhattacharyya
Transfers :
From Graduates to Associate Members
P. Uawithya; E. Walker; W. V. McGrory.

"MISSING" MEMBERS

Correspondence and Journals sent to the following members at the addresses shown are returned to Head Office by the Post Office. Any information regarding the present whereabouts of these members would be appreciated by the Institution's Records Department.

K. N. Aggarwal, Grad.I.Prod.E.,
Box 50, Lehigh University,
Bethlehem, Pa.,
U.S.A.

G. U. Ahmed, Grad.I.Prod.E.,
103 Park Road,
Peterborough,
Northants.

W. J. Anderson, M.I.Prod.E.,
9 Lochend Road,
Troon,
Ayrshire.

J. Ramsey Andrew, A.M.I.Prod.E.,
18 Hertford Street,
London, W.1.

R. Archer, A.I.Prod.E.,
80 Fairview Road,
Sheffield, 5.

R. C. Atkins, A.M.I.Prod.E.,
"Colwyn",
Peterborough Road,
Farcet, Peterborough.

V. J. Basham, Stud.I.Prod.E.,
57 Dulverton Avenue,
Park Estate,
Swindon, Wilts.

F. W. Bates, A.M.I.Prod.E.,
292 Ralph Road,
Shirley, Solihull,
Warwicks.

J. G. Beasley, Grad.I.Prod.E.,
"Gale End",
Springhill Lane, Lower Penn,
Wolverhampton.

M. E. Bell, A.M.I.Prod.E.,
16 Cavendish Road,
Ayleston, Leicester.

W. G. Beauchamp, M.I.Prod.E.,
90 Old Holywood Road,
Belfast,
N. Ireland.

H. Bibby, A.M.C.T., A.M.I.Prod.E.,
173 Windsor Road,
Oldham,
Lancs.

E. G. Bones, A.M.I Prod.E.,
16 Greenfield Road,
Oakdale,
Poole, Dorset.

A. D. Boyd, A.M.I.Prod.E.,
27 Pioneer Street,
Salisbury,
Southern Rhodesia.

C. Broad, A.M.I.Prod.E.,
20 Altson Road,
Moffats View,
Johannesburg, South Africa.

E. A. Brooks, Grad.I.Prod.E.,
28 Furze Hill Road,
Boreham Wood,
Herts.

R. A. R. Buck, Grad.I.Prod.E.,
412 Peel Street,
Whitby,
Ontario, Canada.

Joseph Butler, M.I.Prod.E.,
Kebroyd,
385 Perth Road,
Dundee.

W. T. Campbell, Grad.I.Prod.E.,
7 King Street, Paisley,
Renfrewshire,
Scotland.

R. A. Chalmers, A M.I.Prod.E.,
c/o Gilbert Lodge & Co. Ltd.,
126 Sussex Street,
Sydney, N.S.W., Australia.

E. S. Charlton, A.M.I.Prod E.,
Park Chambers,
77 High Street North,
Dunstable, Beds.

M. G. Cherry, Grad.I.Prod.E.,
93 Clarence Gate,
Baker Street,
London, N.W.1.

G. Clancey, A.M.I.Prod.E.,
Messrs. G. Clancey Ltd.,
New Street,
West Bromwich.

A. E. Clark, A.M.I.Prod.E.,
312 Tudor Drive,
Kingston-on-Thames,
Surrey.

K. Clarke, A.M.I.Prod.E.,
P.O. Box 106,
Jeppe,
Johannesburg, South Africa.

S. J. Cook, A.M.I.Prod.E.,
2 The Keep,
Castle Hill, East Leake,
Loughborough, Leics.

T. K. Cordes, A.I.Prod.E.,
P.O. Box 9623,
Johannesburg, South Africa.

Malcolm Crabbe, M.I.Prod.E.,
Eden Gardens,
Banham,
Norfolk.

G. V. Dawbarn, A.M.I.Prod.E.,
34 Redhatch Drive,
Earley,
Reading.

M. Docherty, M.I Prod.E.,
c/o Consolidated Textile Mills,
P.O. Box 395,
East London, Cape Province.

C. O. Doehring, M.I.Prod.E.,
Kingsbury Hotel, Kei Apple Road,
Sea Point,
Cape Town, South Africa.

W. Donaldson, A.M.I.Prod.E.,
4 Edwards Street,
Burwood,
Victoria, Australia.

K. C. Eastop, Grad.I.Prod.E.,
39 Matai Road,
Green Lane, Auckland, S.E.4.,
New Zealand.

N. Edmanson, A.M.I.Prod.E.,
3 Clayton Close,
Blakenhall,
Wolverhampton.

A. C. S. Ensell, Grad.I.Prod.E.,
Apt. 206, Ridgeway Apartments,
3225 Ridgewood Avenue,
Montreal, P.Q., Canada.

G. G. Fenton, A.M.I.Prod.E.,
80 Beacon Way,
Rickmansworth,
Herts.

R. W. Finney, Grad.I.Prod.E.,
45 Severn Road,
Stonehouse,
Glos.

A. Fowell, Stud.I.Prod.E.,
10 West View,
Beeston,
Leeds, 11.

R. S. Franks, A.I.Prod.E.,
Clay Block Association,
Africa House, Kingsway,
London, W.C.2.

J. Fray, G.R.Ae.S., Grad.I.Prod.E.,
25 Leach Street,
Prestwich,
Manchester.

J. G. Garlick, Stud.I.Prod.E.,
Lot 27,
McDonald Avenue,
Earlwood, N.S.W., Australia.

K. Ghatak, Grad.I.Prod.E.,
Steam Turbine Department,
Allis-Chalmers Mfg. Co.,
Milwaukee, Wisconsin, U.S.A.

A. V. Gibson, A.M.I.Prod.E.,
42 Clarendon Road,
Herne Bay,
N.S.W., Australia.

A. L. Glen, A.M.I.Prod.E.,
Flat 1, 82 Devenish Street,
Pretoria, South Africa.

T. H. Goddard, A.M.I.Prod.E.,
17 Broadway,
Lincoln.

A. A. Goldring, Grad.I.Mech.E.,
Grad.I.Prod.E.,
Apt. 29, 3203 Clayten Road,
Concord, California, U.S.A.

D. I. Gray, Grad.I.Prod.E.,
42 Longacre Road,
Walthamstow,
London, E.17.

L. J. Guest, A.M.I.Prod.E.,
16 Bastfield Crescent,
Harrow,
Middx.

T. E. H. Gwyer, M.B.E., M.I.Prod.E.,
18 Alice Street,
Brantford,
Ontario, Canada.

J. R. Haddow, Grad.I.Prod.E.,
38 Moorfield Avenue,
Kilmarnock,
Ayrshire.

H. N. Hamilton, A.M.I.Prod.E.,
Glen Moray 15, Third Avenue,
Hill Extension,
Johannesburg, South Africa.

A. J. Hatton, Grad.I.Prod.E.,
Snowy Mountain Hydro Authority,
Coomba,
N.S.W., Australia.

W. M. Harrison, Grad.I.Prod.E.,
14 Gilchrist Street,
Vanderbilt Park,
Transvaal, South Africa.

E. T. Hartley, A.M.I.Prod.E.,
Weald House,
St. Neots,
Hunts.

Major General W. F. Hasted, C.B.E.,
M.I.Prod.E.,
Bayside, Appledore,
Bideford, Devon.

H. Heselton, F.I.F.M., A.M.I.Prod.E.,
14 Cliveden Avenue,
Perry Bar,
Birmingham, 22.

D. M. F. Heymans, A.M.I.Prod.E.,
10 Seventh Avenue,
Hillside, Beaufort West,
South Africa.

E. H. Holder, A.I.Mech.E.,
A.F.R.Ae.S., M.I.Prod.E.,
Manager, Royal Ordnance Factories,
c/o Senior Officers Mess,
Wah Cannt., West Pakistan.

R. L. W. Holder, Stud.I.Prod.E.,
1042 Tyburn Road,
Pype Hayes,
Birmingham, 24.

E. W. Hope, Stud.I.Prod.E.,
Box 403,
Malton,
Ontario, Canada.

J. B. Hoyle, Stud.I.Prod.E.,
206 Boultham Park Road,
Lincoln.

L. G. Humble, A.M.I.Mech.E.,
M.I.Prod.E.,
"Martessa", Station Road,
Balsall Common, Warwicks.

Ralph J. A. Hylton, A.M.I.Prod.E.,
89 Wardown Crescent,
Luton,
Beds.

G. Jackson, A.M.I.Prod.E.,
46 Lower Dolcliffe Road,
Mexborough,
Yorks.

M. D. L. John, Stud.I.Prod.E.,
51 Briar Road,
Kingswood,
Watford, Herts.

A. E. Judd, A.M.I.Prod.E.,
29 Clarence Place,
Gravesend,
Kent.

J. H. Kane, Grad.I.Prod.E.,
4 Ellesmere Drive,
Shrewsbury.

Harry Kay, A.M.I.Prod.E.,
17 Markland Hill Lane,
Bolton,
Lancs.

R. F. W. Keay, A.M.I.Prod.E.,
90 Risbygate Street,
Bury St. Edmunds,
Suffolk.

G. Keeble, A.M.I.Prod.E.,
"Gwenter",
The Circle, Mereside Road, Mere,
Knutsford, Cheshire.

D. K. Keene, Grad.I.Prod.E.,
1714 Emerson Street,
Philadelphia, I.S.,
Pennsylvania, U.S.A.

F. R. Kelly, A.M.I.Prod.E.,
"Arlington",
Heatherton Road, Dandenong,
Victoria, Australia.

W. D. Kendall, M.P., M.I.Prod.E.,
"Brusa",
Belton Lane,
Grantham, Lincs.

A. Mcl. Knox, A.M.I.Prod.E.,
Shell Co. of Turkey Ltd.,
Beyoglu P.O. Box 542,
Istanbul, Turkey.

J. D. Kritzinger, Stud.I.Prod.E.
55 Juta Street,
Braafontein,
Johannesburg, South Africa.

J. P. Laidlaw, A.M.I.Prod.E.,
34 Onyx Street, Kensington,
Johannesburg,
South Africa.

W. A. Leach, Grad.I.Prod.E.,
48 Whitehouse Crescent,
Sutton Coldfield,
Warwicks.

E. Lewis, M.I.Prod.E.,
Jermiston Engineering Co. (Pty.) Ltd.,
P.O. Box 207,
Roodpoort, South Africa.

W. A. P. Lewis, A.M.I.Prod.E.,
9 Ashfield Road
Aigburth,
Liverpool.

E. F. Lines, Grad.I.Prod.E.,
10 Eastlands Grove,
Coventry.

J. Lister, A.M.I.Mech.E., A.M.I.Prod.E.,
c/o Africa Explosives & Chemical Industries, Modderfontein Dynamite Factory,
P.O. Northrand, Transvaal,
South Africa.

C. W. Longhurst, A.M.I.Prod.E.,
161 Burnage Lane,
Burnage,
Manchester, 19.

J. Longley, A.M.I.Prod.E.,
1 Chestnut Road,
Downend,
Bristol.

G. H. Lonsdale, A.M.I.Prod.E.,
141 Jeffereyes Crescent,
Roby,
Nr. Liverpool.

S. G. Maine, A.M.I.Prod.E.,
30 Nymph Street,
Kensington,
Johannesburg.

C. K. Malhan, Grad.I.Prod.E.,
25 Junction Road,
Sheffield, 11.

L. Marshall, A.M.I.Prod.E.,
21 Bernard Avenue,
Appleton,
Warrington.

P. A. Martin, B.Sc., G.I.Mech.E., Grad.I.Prod.E.,
29 Wilson Street,
Beith, Ayrshire.

J. J. McGowan, Stud I.Prod.E.,
166 Downside Road,
Glasgow, S.W.3.

J. A. C. McIntosh, A.M.I.Prod.E.,
188 Venice Road,
Morningside,
Durban, Natal.

R. Mead, A.M.I.Prod.E.,
"Bascote",
49 Garendon Road,
Loughborough, Leics.

Lionel H. Milsom, A.M.I.Prod.E.,
57 Long Dales Road,
Lincoln.

H. W. Milstead, A.M.I.Prod.E.,
Kew Hotel,
Nuttall Gardens,
Durban, South Africa.

E. G. Moody, Stud.I.Prod.E.,
80 Parsonage Barn Lane,
Ringwood,
Hants.

C. J. Morgan, A.M.I Prod.E.,
433 Guildford Road,
Guildford,
N.S.W., Australia.

Jan D. J. De Necker, A.M.I.Prod.E.,
P.O. Box 531,
Bloemfontein,
O.F.S., South Africa.

D. A. Oliver,
Wm. Jessop & Sons Ltd.,
Kingsway Chambers,
44 - 46 Kingsway, London, W.C.1.

Walmer De Palo, A.I.Prod.E.
c/o Pretoria Metal Industries,
P.O. Box 1396,
Pretoria, South Africa.

R. Parker, A.M.I.Prod.E.,
2 Maple Avenue,
Horwich,
Nr. Bolton, Lancs.

S. A. Pearson, A.M.I Prod.E.,
60 Woods Avenue,
Hatfield,
Herts.

H. W. Pellow, A.M.I.Prod.E.,
P.O. Box 533,
Springs, Transvaal,
South Africa.

P. R. Pelly, A.M.I.W.M., M.I.Prod.E.,
"Westfield House",
Notgrove, Nr. Bourton-on-the-Water,
Glos.

E. J. Peplow, M.I.Prod.E.,
Blackmore Vale Filling Station,
Sherborne Causeway,
Nr. Shaftesbury, Dorset.

H. J. Ping, M.I.Prod.E.,
47 Willifield Way,
London, W.11.

J. A. Plumley, Stud.I.Prod.E.,
11 Ravensthorpe,
Luton,
Beds.

P. J. Pope, Grad.I.E.E., Grad.I.Prod.E.,
115 Mortlake Road, Kew,
Richmond, Surrey.

R. A. Powley, A.M.I.Prod.E.,
11610 La Salle Boulevard,
Apt. 202, Detroit 6,
Michigan, U.S.A.

P. Powell, B.Sc., Grad.I.Prod.E.,
15a Wayside Avenue,
Harrogate,
Yorks.

A. S. Rachman, Grad.I.Prod.E.,
c/o Barclays Bank,
Adderley Street, Cape Town,
South Africa.

J. B. Rankine, A.M.I.Prod.E.,
19 Holt Avenue,
Mosman,
N.S.W., Australia.

J. D. Rowe, A.M.I.Prod.E.,
"The Beeches",
2 School Lane, Weston Turville,
Nr. Aylesbury, Bucks.

J. Roznak, A.M.I.Prod.E.,
29 Elmwood Gardens,
Gateshead, 11.

J. W. Rumley, G.I.Mech.E., A.M.I.Prod.E.,
30 Seagrave Road,
Oadby, Leicester.

A. A. V. Ryan, A.M.I.Prod.E.,
16 Connaught Avenue,
Sandringham,
Johannesburg, South Africa.

J. T. Rymer, M.I.Prod.E.,
Mayfield Lodge,
Mayfield Drive,
Shrewsbury, Shropshire.

L. Salinas-Estenssoro, S.I.Mech.E., Grad.I.Prod.E.,
V. Beverningkst, 2,
Den Haag, Holland.

G. Sanders, A.I.Prod.E.,
"Northedge",
41 Newport Road,
Cowes, I.O.W.

J. R. Sareen, Grad.I.Prod.E.,
Loughborough College of Technology,
Loughborough,
Leics.

S. Scott, A.M.I.Prod.E.,
20 Blenheim Avenue,
Surrey Hills, Melbourne,
Victoria, Australia.

P. Seassau, Grad.I.Prod.E.,
157 Rue De L'Universite,
Chez Mlle Corbes,
Paris 7E., France.

H. Selinger, A.M.I.Prod.E.,
c/o Ott, Hasenbergsteige, 70,
Stuttgart,
West Germany.

D. D. Shrewsbury, M.B.E., A.M.I.Mech.E., A.M.I.Prod.E.,
"Pennant", Start Lane,
Whaley Bridge, Via Stockport,
Derbyshire.

A. R. J. Simon, Stud.I.Prod.E.,
c/o Box 4256,
Johannesburg,
South Africa.

K. K. Sinha, Stud.I.Prod.E.,
c/o Messrs. Greenwood & Batley Ltd.,
Albion Works,
Armley Road, Leeds, 12.

J. E. Slade, A.M.I.Prod.E.,
92 Hannah Street,
Croydon,
Sydney, Australia.

Arthur Smith, M.I.Prod.E.,
693 Barnsley Road,
Sheffield, 5.

A. H. Smith, A.M.I.Prod.E.,
82 Willoughby,
Kenmare,
Krugersdorf, South Africa.

C. A. Stellakis, S.I.Mech.E., Grad.I.Prod.E.,
16 Sunderland Road,
South Shields, Co. Durham.

B. Stevens, Stud.I.Prod.E.,
"Oakworth",
171 Pooltown Road, Ellesmere Port,
Wirral, Cheshire.

R. C. Studdart, Grad.I.Prod.E.,
118 Wilbur Street,
Lakemban,
S.W. Australia,

F. J. Sheils, Grad.I.Prod.E.,
5860 Deccelles Avenue,
Apt. B., Montreal,
Quebec, Canada.

J. E. Strick, M.I.Prod.E.,
c/o Australian Electrical Industries (Pty.) Ltd.,
P.O. Box 9, Graville,
Sydney, Australia.

C. G. Suters, A.M.I.Prod.E.,
41 Cambridge Terrace,
Hower Hutt,
New Zealand.

R. E. Sykes, B.Sc. S.I.Mech.E., Grad I.Prod.E.,
23 Chepstow Villas,
Kensington, London.

K. Tarrell, A.M.I.Prod.E.,
c/o French Engineering Works Ltd.
P.O. Box 4526,
Johannesburg, South Africa.

J. G. Temple, B.Sc.(Eng.), G.I.Mech.E., Grad.I.Prod.E.,
51 Sotheby Avenue,
Sutton-in-Ashfield, Notts.

R. Thomson, A.M.I Prod.E.,
58 Newry Park,
Chester.

A. D. Tompkinson, Stud.I.Prod.E.,
104 Sinclair Avenue,
Banbury,
Oxon.

Col. C. C. L. Tofield, C.B.E., M.I.Prod.E.,
c/o Production Tool Alloy Co. Ltd.,
Harlington Works, Harlington Road,
Sharpenhoe, Beds.

A. Tooley, Stud.I.Prod.E.,
66 Rosebank Grove,
Westfield Road,
Leeds, 3.

M. J. Wade, Stud.I.Prod.E.,
2 Box Close,
Creekmore Farm Estate,
Fleet Bridge, Poole, Dorset.

D. N. Waite, Stud.I.Prod.E.,
c/o Mrs. Wilson,
51 Somerset Road,
Handsworth Wood, Birmingham, 20.

G. L. Whitby, Stud.I.Mech.E., Grad.I.Prod.E,
3 Baddeley Street,
Burslem,
Stoke-on-Trent, Staffs.

C. V. Williams, A.M.I.Prod.E.,
37 Kitts Moss Lane,
Bramhall,
Nr. Stockport, Cheshire.

D. J. Williams, A.M.I.Prod.E.,
c/o P.O. Box 5990,
Johannesburg,
South Africa.

J. C. Williams, F.B.H.I., A.M.I.Mech.E., A.M.I.Prod.E.,
98 Regina Road,
Southall, Middx.

John R. Williams, Grad.I.Prod.E.,
16 Cranbrook Avenue,
Roseville,
Sydney, Australia.

M. Williams, Grad.I.Prod.E.,
26 Fairfield Street,
Mt. Hawthorn,
W. Australia.

J. A. Wood, A.M.I.Prod.E.,
c/o Fillerys (Pty.) Ltd.,
P.O. Box 6560,
Johannesburg, South Africa.

J. K. H. Wong, M.I.Prod.E.,
15 Galveston Road,
Putney,
London, S.W.15.

Edward N. Vincent, M.I.Prod.E.,
"Kilbirnie",
25 Barke Road, Strathfield,
N.S.W., Australia.

DIARY FOR 1960

APRIL 23 ... ... **North Midlands Regional Conference, Derby**
Theme: **"The Production Engineer in a Changing Economy"**

MAY 11 ... ... **Sixth Conference of Engineers Responsible for Standards**, at the Connaught Rooms, London. (See Supplement.)

JUNE 27 ... ... **Summer Meeting,** at the Festival Hall, London, preceded by **The 1960 Viscount Nuffield Paper,** at The Royal Institution, London (see Journal Supplement).

AUGUST 24 - 28 ... ... **Symposium,** at The College of Aeronautics, Cranfield.
Subject: **"Machine Tool Control Systems"** (See Supplement.)

OCTOBER 19 - 22 ... ... **National Conference,** at Brighton.
Theme: **"Modern Trends in the Manipulation of Metals"**

NOVEMBER 2 ... ... **Annual Dinner,** at the Dorchester Hotel, London.

WESTERN GRADUATES AND THE M.I.

ON Thursday, 28th January, the Western Graduate Section were addressed at the University of Bristol by Mr. J. A. Pymont, the Chief Planning Engineer of the London-Birmingham Motorway. The Large Lecture Theatre, Faculty of Engineering, was packed for the occasion, the attendance being one of the largest at a function of this Section.

Prior to the Lecture, a reception was held by the Section Committee at which the guests were the Senior Section Chairman and Committee, heads of local industry and technical colleges, and the Head of the City Constabulary Traffic Department. The Bristol Motor Club was also represented.

Mr. Pymont opened his talk by describing how the first survey of the Motorway line was undertaken by his firm, John Laing & Son Ltd. Very stringent conditions attached to the contract, particularly in relation to interference with British Railways, G.P.O. and other public services. A heavy penalty payment attached to any delay in completing the Motorway within the stipulated period. After weighing up all the factors, including the imponderable influence of the British weather, the Company submitted tenders for the four contracts that covered the length of the Motorway.

It was with more than a little consternation that the Company received the news that they had been awarded the contracts for all four sections, and the first reaction was to wonder whether they had bitten off more than they could chew!

Mr. S. G. E. Nash, Chairman of the Western Section and the South Western Region (centre) chats with Superintendent Sims (right), Head of the Bristol City Constabulary Traffic Department, and Mr. R. W. Hancock, of the Western Section Committee.

In this group at the reception preceding the lecture are (from left) the speaker, Mr. J. A. Pymont, Chief Planning Engineer, John Laing & Son Ltd.; Mr. D. A. Fairnie and Mr. F. G. Sandiford, of the Western Section Committee; and Mr. R. J. M. Watt, Vice-Chairman of the Western Graduate Section.

By splitting each contract into three or four sections and appointing a manager over each, the problem was cut down into reasonably manageable units. A master plan was, of course, in use for overall control and the co-ordinating team had at their disposal a helicopter for quick communication over the difficult terrain.

The bridge work was put in hand at an early stage of the job and by standardising bridge design, considerable economies were effected in the quantity of moulded concrete shuttering required.

Through the appalling summer of 1958 work proceeded, hampered considerably by floods and mud.

Materials were brought to the site mainly by sub-contractors; cement, gravel, sand, etc., being delivered by lorry to the points required. Concrete was made up at a number of batching plants specially set up along the line of the road. Not the least point was the organisation of fuel supplies for the vast fleet of mechanised equipment.

While the technical and administrative staff were recruited largely from with the Company, the majority of the labour force were recruited specially for the job. "Billeted" for the most part in "digs" in villages and towns bordering the route, the labour worked with enthusiasm to meet the stage dates set for completion of tasks.

The summer of 1959 brought much better conditions, and work proceeded apace to meet the completion target of the first week in November. Soon from the air sections could be seen with the 2½ in. rough tarmac coating in position, contrasting with the whiteness of the two white ribbons of kerb on either side.

The 1½ in. final dressing was rolled in place and the Motorway was ready on time for handing over to Ministry of Transport.

An excellent colour film of the Motorway construction was shown at the meeting.

During the discussion following the lecture, Mr. R. S. Brown, Works Director, Bristol Aircraft Ltd., commented that he had been very impressed indeed with the thoroughness and extent of the planning involved in the Motorway construction.

Mr. Pymont replied to the questions with the same wit and authority with which he had delivered his lecture, and sat down to prolonged applause.

The Graduate Section Chairman, Mr. G. Mossman, called upon the Vice-Chairman to give the vote of thanks, which was seconded by Mr. S. G. E. Nash, the Chairman of the Western Section.

R. J. M. WATT.

WHITWORTH FOUNDATION AWARDS 1961

The Ministry of Education announce for competition in 1961 three Whitworth Fellowships tenable for at least one year and of value £1,000.

To be eligible a candidate must be a British subject, over 25 years of age and in possession of an Engineering Degree in Engineering or a Diploma in Technology (Eng.) or have a Higher National Diploma or Certificate in engineering with at least two distinctions, and to have subsequently engaged as a practising engineer for not less than three years.

The Fellowship can be used to cover a course of training in industry or post-graduate or post-Dip.Tech. study in an approved establishment and/or industrial organisation. Forms 50 F.E., giving details of the 1961 awards, have been issued by the Ministry of Education, and "Rules and Conditions for the Award of Whitworth Fellowships and Exhibitions" may be obtained, price 4d. net (by post 6d.) from H.M. Stationery Office, York House, Kingsway, London, W.C.2., or through any bookseller.

WORKING CONFERENCE ON MEASUREMENT AND MANAGEMENT

The West of England Region of the Work Study Society have organised a Working Conference on "Measurement and Management" to be held at The Grand Atlantic Hotel, Weston-super-Mare from 22nd - 24th April, 1960. Papers will be given on "The Nature and Measurement of Industrial Fatigue"; "The Compilation and Application of Relaxation Allowances"; "Cybernetics and Operational Research"; and The British Standard Glossary of Terms in Work Study.

Full particulars of the Conference may be obtained from the Conference Secretary, Department of Work Study and Staff Training, Engineers' House, Promenade, Bristol, 8. The final date for receipt of applications is 16th APRIL.

NEWCASTLE UPON TYNE DINNER-DANCE

This photograph, taken on the occasion of the Annual Dinner-Dance given by the Newcastle upon Tyne Section, on 20th January last, includes (from left) Lieutenant-Commander Lakin; Sir William Scott; Mr. G. Ronald Pryor, President of the Institution; Mr. F. Robinson, Section and Northern Region Chairman and Mr. J. B. Jackson, Chairman of the North Eastern Branch of the Institution of Mechanical Engineers and Regional Controller, North Eastern Electricity Board.

OBITUARY

The Institution records with deep regret the death on 4th February, 1960, of Mr. **John Smedley,** Member. He was a prominent member of the Institution for many years, and at the time of his death was Chairman of the Derby Section, and a member of the North Midlands Regional Committee.

Mr. Smedley, who had been Chief Production Engineer of Rolls-Royce Ltd., Aero Engine Division, since 1955, had been associated with the Company for 42 years, from the time of his apprenticeship in 1918. During the Second World War he managed the Ashbourne factory and later the jet engine production factory at Newcastle upon Tyne. In 1946 he returned to Derby as Assistant Works Manager, becoming Works Manager in 1950.

He will be very greatly missed not only by his colleagues in the Rolls-Royce Company, but by his many friends throughout the Institution and the profession generally.

news of members

Mr. J. E. Burnett, Member, who recently joined Flight Refuelling Ltd., has been appointed to the Board as Works Director. Mr. Burnett, who is a past Member of Council, was formerly Director and General Manager of Helliwells Ltd., a subsidiary of Tube Investments Ltd.

Mr. R. S. W. Clarke, C.B.E., Member, has been appointed Director of Management Studies, REME Officers School, REME Training Centre, Arborfield.

Mr. F. W. Halliwell, C.B.E., Member, Chairman and Joint Managing Director of Gay's (Hampton) Ltd., becomes Immediate Past President of The Gauge & Toolmakers Association.

Sir Stanley Harley, Member, Chairman and Managing Director of The Coventry Gauge and Tool Co. Ltd., has been elected President of The Gauge and Toolmakers Association.

Mr. R. H. Higgs, J.P., Member, Managing Director of Richard Lloyd Ltd., has been appointed a Director of the British Rollmakers Corporation Ltd.

Mr. H. T. Jones, Member, Works Director, who has been an Executive Director for some years, has now been appointed to the main board of Landmaster Ltd., Bucknall, Nottingham.

Mr. C. W. McDonald, Member, has taken up the duties of Production Manager at Messrs. Villiers Engineering Co. Ltd., Wolverhampton.

Mr. R. S. Odd, Member, has relinquished his position as Director and General Manager of Wilmot Breeden Ltd., to take up a new appointment as Joint Managing Director of Lansing Bagnall Ltd.

Mr. F. W. Potter, Member, has been appointed to the Board of Rose, Downs & Thompson Ltd., Hull, (a member of the Power-Gas Group), where for a number of years he has been Works Manager.

Mr. W. U. Snell, Member, has now moved from Bristol Aero-Engines Ltd., Bristol, to the Power Division, Bristol Siddeley Engines Ltd., Coventry, where he is Manager of the Industrial Turbine Section. Mr. Snell formerly served on the Western Section Committee.

Mr. R. A. Aitken-Holt, Associate Member, has relinquished his position as Staff and Planning Officer, Electrical and Mechanical Engineers, East African Land Forces Organisation and has taken up an appointment as Principal of the new Kenya Polytechnic, Nairobi.

Mr. B. T. Aston, Associate Member, has taken up the position of General Manager with the Overhill Engineering Co. Ltd., of Holton Heath, Poole.

Mr. G. K. G. Barnett, Associate Member, has taken up an appointment in the Education Department of English Electric Aviation Limited, Guided Weapons Division, Hitchin, Herts.

Mr. G. C. Derbyshire, Associate Member, has been appointed Works and Technical Director of The Jacobs Manufacturing Co. Ltd., and Frank Guylee & Son Ltd.

Mr. J. H. Forrington, Associate Member, formerly General Manager, has been appointed to the Board of D. A. Gunn (Engineering) Ltd., as Works Director.

Mr. A. K. Gill, Associate Member, who was Executive Assistant to Managing Director of Bryce Berger Ltd., Staines, has now been appointed Executive Director of Bryce Berger Ltd., Gloucester.

Mr. J. E. Glasper, Associate Member, has recently taken up an appointment as Production Engineer with Platt Bros. & Co. Ltd., Oldham. Mr. Glasper was the Newcastle upon Tyne Section Corresponding Member on the Papers Committee.

Mr. D. R. Harper, Associate Member, who was Lecturer in Mechanical Engineering at Southall Technical College, has taken up an appointment as Technical Equipment Officer, London County Council.

Mr. J. E. A. Heale, Associate Member, is now General Manager of Works, Associated Electrical Industries (Woolwich) Ltd.

Mr. G. D. Jordan, Associate Member, who has been Senior Engineer in The United Steel Company's Department of Operational Research and Cybernetics since its formation, is now Melting Shop Project Secretary at the Templeborough Works of Steel, Peech & Tozer Ltd.

Mr. H. Kay, Associate Member, has recently left the United Kingdom, for Dandenong, near Melbourne, Australia, for an initial period of two years to set up a new factory on behalf of the English Steel Tool Corporation Ltd.

Mr. J. W. Rose, Associate Member, has relinquished his position as Chief Production Engineer, D. Napier & Son Ltd., and has been appointed Chief of Production Engineering, Richardsons Westgarth (Hartlepool) Ltd., Hartlepool.

Mr. A. W. P. Stephen, Associate Member, formerly Manager, Marketing Services Division of A.E.I.-Hotpoint Ltd., has now been appointed Market Development Manager.

Hazleton Memorial Library

ADDITIONS

Members are reminded of the following Library rule, which is frequently ignored:

"The initial loan period is one month, and borrowers may keep books and periodicals for further periods of one month, if they ask the Librarian, and if no other borrower wants them. Applications for renewal may be made by post or telephone."

London and Home Counties Regional Advisory Council for Technological Education. **"Report on Wastage of Wastage of Students from Part-Time Technical and Commercial Courses."** *London, the Council.* No. 31; 1959. 12 *pages.*

Severe wastage of students is known to occur in many branches of Further Education and indeed has been with us for many years. The rapid growth of part-time day and sandwich release for various courses and the consequential cost to industry underlines the need for research and enquiries into this problem, and therefore, the Report is to be welcomed. The main conclusions reached are:-

Lack of adequate foundation in the basic subjects of English, Mathematics and Science of entrants to Colleges; lack of understanding and co-ordination between Secondary Schools and Colleges; difficulties and lack of research into teaching methods; lack of clarity by industry on its requirements and faulty selection for the numerous courses now held in Colleges. The Report welcomes the establishment of "feeder" Colleges, not least the segregation of junior students and craft classes, again with possible improvements in teaching methods. It is, however, thought that the alleged lack of interest mentioned in the Report, by Heads of Departments in the lower work, is not general and that "come and queue up" method of enrolment is slowly giving way to personal contact between student, Training Officer and the Senior Staff of the College, Two omissions are references to the excellent work done by Youth Employment Officers and also the important part played by parents in the selection of careers. It is thought that the Report will probably be of greatest value in the field of Secondary Education and to the smaller firms.

Institute of Cost and Works Accountants, London. **"An Introduction to Business Forecasting."** *London, the Institute,* 1960. 42 *pages.* 7s. 6d. (Distributed by Gee & Company.)

How management can best set about acquiring the information it needs for effective future planning is the subject of this book, which is primarily intended for accountants, but includes information which would be useful and interesting to others. This is a practical book, which includes many examples of the application of the methods advocated. The two appendices deal respectively with the results of sales forecasting at The Metal Box Company during 12 financial years; and with the preparation of forecasts by Clarkson (Engineers) Ltd.

Contents: Introduction (nature, purpose and types of forecasts) — Forecasts of sales — Forecast of output — forecasts) — Forecast of sales — Forecast of trading results — Forecast of cash position — Forecasts and Standard costs. Appendices: Sales forecasting; an examination of actual results — Preparation of forecasts; a practical example.

McInery, A. S., and Geoghegan, R. S. **"Seminar : Variety Reduction."** *London, British Productivity Council,* 1959. 69 *pages. Charts. Tables. Mimeo.* 30s.

The authors define variety reduction as the elimination of the unnecessary diversity which frequently exists in the various stages from design to manufacture and selling of a product or products. The authors discuss its principles and advantages, and describe its operation with practical examples and statistical data. The elimination of end-product variety is discussed in relation to profits, selling and packaging; and the elimination of variety during the manufacturing cycle is discussed in relation to design, production engineering and manufacturing, and bought out items.

Milward, G. E. **"Organisation and Methods : A Service to Management."** *London, Macmillan,* 1959. 405 *pages. Plates. Folding charts.* 63s.

The Organisation and Methods Traning Council was formed in 1957 by seven large firms which decided to co-operate for a limited period in order to help in promoting in the main industrial centres courses of training in organisation and methods; and to record and disseminate the best practices of the participating firms. The present book has been published in fulfilment of the latter object. It is edited by G. E. Milward, formerly of the Organisation and Methods Department of the Treasury. It includes information about the principles of organisation and methods; organisation and methods techniques and the conduct of an investigation; management of organisation and methods; and the characteristics and advantages of various kinds of office machinery.

Contents: Foreword (by Sir Thomas Hutton) — Suggestions for teaching organisation and methods — Introduction — Verification of purpose — The simplification of office work — Forms design — Clerical aids — Field of office machinery — The assignment — The application of measurement to office work — The measurement of organisation and methods work — Organisation — Background subjects. *Appendices:* EDP procedure chart; EDP block diagrams — Chart: the field of office machinery.

Paist, Walter D. **"Cellulosics."** *New York, Reinhold Publishing Corporation; London, Chapman and Hall,* 1958. 270 *pages. Illustrated. Diagrams. Tables.* 46s. (Reinhold's Plastics Application Series.)

Properties, chemistry fabrication and practical applications of cellulosics. Practical applications dealt with including fibres, moulding powders, films, protective coatings, adhesives, thickening agents. Future trends are surveyed.

Contents: The cellulosics — Chemistry of the cellulosics — General properties of the cellulosics — Fabrication — Applications of extruded and cast cellulosics — Applications of injection moulded cellulosics — Protective coatings — Applications of the cellulosics as adhesives and binders — Miscellaneous applications — Fibres and fabrics — New developments.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF ENGINEERING PRODUCTION

Applications are invited now for admission to the following one-year postgraduate courses beginning October, 1960.

Master of Science Course in Engineering Production *(in the case of non-graduates this course leads to the Diploma in the Principles of Engineering Production and Management and exceptionally to the M.Sc. Degree)*

The primary object of this course, which is now in its eleventh year, is to provide advanced education and training for engineering graduates and others with equivalent qualifications, who have had a minimum of two years' industrial experience.

Course members are required to undertake laboratory and industrial case study work in addition to attending lectures and tutorials in the following subjects :-

Production Management	Production Technology
Productivity Measurement	Product Design and Process Planning
Work Study	Plant Layout and Materials Handling
Applied Statistics	Production Planning and Control

Approximately one-third of the year is devoted to an individual project or investigation leading to the preparation of a report or minor thesis.

Master of Science Course in Operational Research

The object of this course, which was introduced in 1958, is to provide advanced education and training for honours graduates in Science (including Engineering), Mathematics or Economics (with Mathematics and Statistics). Candidates should have already had a minimum of two years' industrial experience and intend to take up careers in Operational Research. The main subjects are :-

Operational Research Techniques	Work Study
Mathematical Statistics	Analogue and Digital Computers
Principles of Engineering Production	Productivity Measurement

Each course member is required to undertake an investigation of a practical industrial problem and to submit a report for examination. Co-operation of industrial companies is sought in the selection of suitable problems and in the provision of facilities for study.

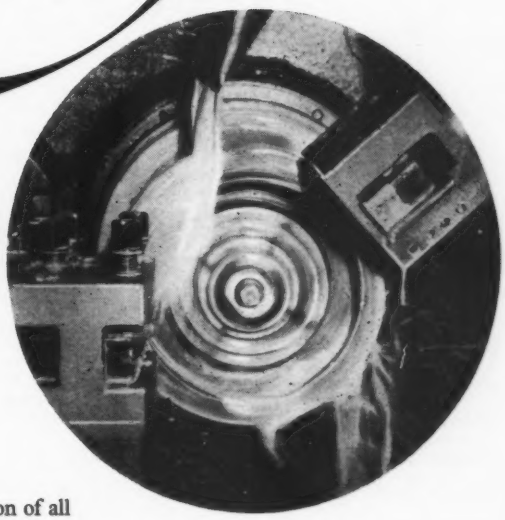
Admission to the above courses is limited to a maximum of 20 Engineering Production students and 6 Operational Research students. Most of those attending are normally sponsored by industrial companies, although funds are available to maintain a small number of independent candidates. The Department of Scientific and Industrial Research has accepted these courses as suitable for the tenure of its Advanced Course Studentships.

Further information may be obtained from :-

PROFESSOR N. A. DUDLEY, Ph.D., M.I.Prod.E.,
HEAD OF THE DEPARTMENT OF ENGINEERING PRODUCTION,
THE UNIVERSITY,
BIRMINGHAM, 15.

SKF
USE
DIXOL
SOLUBLE OILS

INDUSTRIAL
WAKEFIELD-DICK
LUBRICANTS



The name of SKEFKO is known to engineers the world over. This company is the only British manufacturer of all four basic types of bearing, ball, cylindrical roller, taper roller and spherical roller. Each is the very finest of its type and the perfection of all is due in no small measure to DIXOL Cutting Oils. Where high finish and critical accuracy go together, DIXOL Cutting Oils are almost always part of the process. Your cutting operations could very well be made more efficient with DIXOL. Why not invite one of our technicians to look at your machines. He may have some helpful suggestions to make, and of course his advice will cost you nothing.

WAKEFIELD-DICK INDUSTRIAL OILS LTD.

CASTROL HOUSE, Marylebone Road, London, N.W.1.
A member of the world-wide Wakefield Castrol Group.

There's talk of Sykes in the boardrooms...

The works director of a well-known British company recently telephoned the Sykes factory at Staines. He explained that his firm wished to increase the horse-power of an existing engine without altering the structural design of the gear box. Was it possible, he wanted to know, to achieve this by the use of Sykes double-helical gears; would the consequent increased power give rise to undue noise and vibration; and, most important, would the modification step up his production costs?

Fortunately for him, this was the sort of problem which Sykes are exceptionally well qualified to tackle. Years of work at their main business of supplying first-class gear generating equipment—hobbers, shavers, shapers, cutters—have left them with a rich store of practical experience and expert knowledge. And through their Technical Sales Advisory Service, this accumulated knowledge is available to anyone who wishes to benefit from it.

In this particular case, for example, Sykes sent a technical representative to examine the designs for the job. As a result Sykes advised certain additional modifications to the gears; and then—although this was not strictly in their field—their long experience enabled them to suggest how any possibility of noise problems could be avoided by a small internal adjustment to the housing.

Talk to SYKES about gear production

W. E. SYKES LTD · STAINES · MIDDLESEX · ENGLAND and associated companies: Sykes Tool Corporation Ltd, Georgetown, Ontario, Canada
Sykes Machine & Gear Corporation, Newark, NJ, USA · W. E. Sykes Ltd, Mascot, Sydney, NSW, Australia

The Council of the Institution

1959/1960

President

G. Ronald Pryor

Vice-President

H. Burke

Chairman of Council

H. W. Bowen, O.B.E.

Vice-Chairman of Council

R. H. S. Turner

Immediate Past Chairman of Council

H. G. Gregory

Past Presidents

Major-General K. C. Appleyard, C.B.E. Sir George Bailey, C.B.E. E. W. Hancock, O.B.E. The Rt. Hon. the Earl of Halsbury Sir Leonard Lord, K.B.E. The Rt. Hon. Viscount Nuffield, C.H., G.B.E. Sir Walter Puckey Norman Rowbotham, C.B.E. J. D. Scaife Dr. H. Schofield, C.B.E. The Rt. Hon. the Lord Sempill, A.F.C. Sir Cecil Weir, K.C.M.G., K.B.E., D.L., M.C.

Presidents of Councils outside the United Kingdom

Australian Council — J. M. Steer
South African Council — T. H. Hunter

Chairmen of Regional Committees

East & West Ridings
H. Crompton

Eastern
K. S. Jewson

Midlands
H. Tomlinson

North Midlands
A. G. Clark

Northern
F. Robinson

North Western
H. Mason

Northern Ireland
J. L. Fromson

Scotland
R. W. Mackay

South Eastern
A. L. Stuchbery

Southern
H. P. Mott

South Western
S. G. E. Nash

Wales
H. G. H. Dixon

Additional Representatives on Council

East & West Ridings
R. W. Asquith

Midlands
T. W. Elkington

North Western
J. H. Winskill

South Eastern
J. L. Gwyther

Chairmen of Standing Committees

B. E. Stokes (*Editorial*) B. G. L. Jackman (*Research and Technical*) F. C. Cooke (*Papers*) L. W. Bailey (*Library*) W. G. Ainslie (*Education*) R. E. Mills (*Standards*) A. Betts Brown (*Membership*)

Elected Members

G. R. Blakely C. T. Butler R. S. Clark J. V. Connolly N. A. Dudley B. H. Dyson E. Percy Edwards P. H. W. Everitt J. France B. C. Harrison E. Levesley R. N. Marland Dr. T. U. Matthew S. G. E. Nash J. Silver H. Unsworth R. J. C. Whitaker G. A. J. Witton

Chairmen of Sections outside the United Kingdom where Councils are not established

Bombay
A. Miller

Canada
S. S. Pritchard

Calcutta
T. R. Gupta

New Zealand
J. C. Fantham

Overseas Councils

AUSTRALIA

President
J. M. Steer

Chairman
E. J. W. Herbert

Immediate Past President
W. Gwinnett

Vice-Chairman
H. J. Baker

Honorary Secretary
L. W. Worthington

Honorary Treasurer
K. G. Slorach

Delegates

J. G. Brookman, B. H. Coombes, R. W. Deutsher, S. Downie, N. L. Eaton, N. A. Esserman, P. E. Frye, C. A. Gladman, E. J. W. Herbert, A. G. Jones, J. S. Murphy, A. E. Newcombe, F. W. Penny, C. Pullen

SOUTH AFRICA

President
C. J. Mogford

1st Vice-President
D. A. Petrie

2nd Vice-President
G. G. Tardrew

Past Presidents

A. B. Anderson, R. H. Arbuckle, L. H. L. Badham, D. N. S. Clare, W. G. Gillespie, H. J. G. Goyns, J. Henry, T. H. Hunter, D. Lion-Cachet, J. Renwick, D. E. Hamm

Elected Members

R. W. Chapple, G. T. Chawner, E. H. Dallas, P. C. Ellett, D. A. Horton, M. McKenzie Hunter, G. K. Melvill, H. H. Waters, R. Young

---

SECTION CHAIRMEN

H. J. Baker ..... *Adelaide*
J. Silver ..... *Birmingham*
A. Miller ..... *Bombay*
T. R. Gupta ..... *Calcutta*
S. S. Pritchard ..... *Canada*
H. G. H. Dixon ..... *Cardiff*
W. C. Hosken ..... *Cornwall*
A. S. Dick ..... *Coventry*
A. G. Clark ..... *Derby*
G. L. A. Draper ..... *Doncaster*
R. W. Mackay ..... *Dundee*
R. Grant ..... *Edinburgh*
G. V. Stabler ..... *Glasgow*
D. Stocks ..... *Gloucester*
R. W. Asquith ..... *Halifax & Huddersfield*
L. L. Bott ..... *Ipswich & Colchester*
R. Shilton ..... *Leeds*
R. M. Evans ..... *Leicester*
J. Cunningham, M.B.E. ..... *Lincoln*
H. O. Pate ..... *Liverpool*
G. A. J. Witton ..... *London*
G. Kelly ..... *Luton*
H. C. Knott ..... *Manchester*
E. J. W. Herbert ..... *Melbourne*
J. C. Fantham ..... *New Zealand*
F. Robinson ..... *Newcastle upon Tyne*
J. L. Fromson ..... *Northern Ireland*
W. A. Pitt ..... *Norwich*
B. A. Green ..... *Nottingham*
L. P. Coombes ..... *Oxford*
L. P. Simpson ..... *Peterborough*
W. L. Jones ..... *Preston*
H. P. Mott ..... *Reading*
R. Bradford ..... *Rochester*
H. Steel ..... *Sheffield*
S. L. Robinson ..... *Shrewsbury*
C. J. Mogford ..... *South Africa*
E. S. Hammett ..... *South Essex*
J. S. Hopkinson ..... *Swansea*
J. B. Turner ..... *Southampton*
H. A. Armstrong ..... *Stoke-on-Trent*
C. S. Curtis ..... *Sydney*
N. E. Langdale ..... *Tees-Side*
S. G. E. Nash ..... *Western*
P. J. Shipton ..... *Wolverhampton*
J. D. Nicholls ..... *Worcester*

GRADUATE SECTION CHAIRMEN

D. W. Edwards ..... *Birmingham Graduate*
B. Brewster ..... *Coventry Graduate*
D. Rose ..... *Leeds Graduate*
R. O. Jones ..... *Liverpool Graduate*
P. Trosset ..... *London Graduate*
R. H. Cannon ..... *Luton Graduate*
R. C. Yarnell ..... *Manchester Graduate*
E. K. Stephenson ..... *Melbourne Graduate*
P. G. Jenkins ..... *Newcastle upon Tyne Graduate*
G. E. Lawson ..... *Rochester Graduate*
P. W. Wells ..... *Sheffield Graduate*
T. G. Mossman ..... *Western Graduate*
F. J. Silvester ..... *Wolverhampton Graduate*

REGIONAL HONORARY SECRETARIES

East & West Ridings ... J. Keightley
Eastern ... ... A. B. Brook
Midlands ... ... A. C. Turner
North Midlands ... ... J. Cox
Northern ... ... T. Young
North Western ... ... J. P. Speakman
Northern Ireland ... ... J. G. Easterbrook
Scotland ... ... J. Nicolson Low
South Eastern ... ... J. Aikman
Southern ... ... W. F. Reid
South Western ... ... A. Eustace
Wales ... ... A. E. Haynes

SECTION HONORARY SECRETARIES

AUSTRALIA

Adelaide (South Australia) ...	B. H. M. Coombes, 11 Elmo Avenue, Westbourne Park, Adelaide, Australia.
Melbourne (Victoria, Australia)	A. G. Jones, 13 Laburnum Street, Middle Brighton, Victoria, Australia.
Melbourne Graduate (Victoria Australia)	E. P. H. James, 455 Stephenson Road, Mount Waverley, Melbourne, Victoria, Australia.
Sydney (New South Wales)	K. G. Slorach, 98 Church Street, Castle Hill, New South Wales, Australia.

CANADA

Canada	A. M. Hand, 18 Rintella Court, Scarborough, Ontario, Canada.

INDIA

Bombay	R. D. Mistry, "Churchgate House", 32 Veer Nariman Road, Bombay, India.
Calcutta	P. J. O'Leary, c/o Guest, Keen, Williams Ltd., 41 Chowringhee Road, Calcutta, India.

NEW ZEALAND

New Zealand	A. F. Noutch, 6 Trafalgar Road, Milford, Auckland, New Zealand.

SOUTH AFRICA

South Africa	A. Aitken, 209-211 Pharmacy House, 80 Jorissen Street, Johannesburg, P.O. Box 10837 South Africa.

UNITED KINGDOM

Birmingham	W. Silberbach, 44 Linwood Road, Handsworth, Birmingham, 21.
Cardiff	A. E. Haynes, c/o A. B. Metal Products Ltd., Abercynon, Glamorgan.
Cornwall	F. G. Hawke, 3 Bellevue Terrace, East Hill, Tuckingmill, Camborne, Cornwall.
Coventry	A. S. Hopkins, 39 Oaks Road, Kenilworth, Warwicks.
Derby	P. Warburton, 16 Vicarage Road, Chellaston, Derby.
Doncaster	G. R. Wimpenny, 16 Tickhill Square, Denaby Main, Doncaster.
Dundee	A. J. Fraser, 51 Fintry Drive, Dundee.
Edinburgh	D. A. Bowman, The Scottish Council (Dev. and Ind.), 1 Castle Street, Edinburgh.
Glasgow	W. H. Marley, North British Locomotive Co. Ltd., Springburn, Glasgow, N.1.
Gloucester	B. E. Gwynne Clarke, "Chez-Nous", Okus Road, Charlton Kings, Cheltenham.
Halifax & Huddersfield ...	C. W. Overin, 353 Whitehall Road, Westfield, Wyke, near Bradford, Yorks.
Ipswich & Colchester ...	M. D. Blake, Davey, Paxman & Co. Ltd., Standard Ironworks, Colchester, Essex.
Leeds	J. Keightley, 42 Kingsley Avenue, Adel, Leeds, 16.
Leicester & District	J. A. Stovin, 14 Queens Drive, Leicester Forest East, Leicester.
Lincoln	H. Wright, 101 Longdales Road, Lincoln.
Liverpool	H. Mason, 51 Stairhaven Road, Liverpool, 19.
London	H. R. H. Palmer, Creed & Co. Ltd., Telegraph House, Croydon, Surrey.
Luton	J. F. W. Galyer, Engineering Department, Luton & South Bedfordshire College of Further Education, Park Square, Luton, Bedfordshire.
Manchester	J. P. Speakman, 223 Douglas Road, Atherton, near Manchester.
Newcastle upon Tyne ...	L. R. Douglass, Gateshead Technical College, Durham Road, Gateshead, Co. Durham.
Northern Ireland	J. G. Easterbrook, "Hilleen", 22 Ascot Park, Knock, Belfast.
Norwich	J. I. Hilder, 2a Gorse Road, Thorpe, Norwich.
Nottingham	K. Liquorish, 28 Mona Street, Beeston, Nottingham.
Oxford	K. F. Watson, 30 Stanway Road, Headington, Oxford.
Peterborough	N. Holmes, "Arncliffe", 11 Mary Armyn Road, Orton Longueville, Peterborough.
Preston	W. H. Preston, 25 Clifton Avenue, Leyland, Lancashire.
Reading	P. J. Smallbone, "Maryfield", Darlington Road, Basingstoke, Hants.
Rochester & District ...	W. G. Clements, 11 Charing Road, Gillingham, Kent.
Sheffield	W. Edwards, c/o E. Pryor & Son Ltd., West End Works, Broom Street, Sheffield, 10.
Shrewsbury	W. M. Buchan, Llanberis, 36 Mytton Oak Road, Shrewsbury.
Southampton	J. W. Taylor, High Mead, Kane's Hill, Thornhill, Southampton.
South Essex	F. Hopkinson, "Woodley", 40 Highfield Road, Chelmsford, Essex.
Stoke-on-Trent	W. Elliott, 1 Longview Avenue, Alsager, Stoke-on-Trent.
Swansea	C. L. Clarke, 11 Alder Road, Cimla, Neath, South Wales.
Tees-Side	W. Roberts, "Rosecroft", Thirsk Road, Yarm-on-Tees, Yorkshire.
Western	A. Eustace, 19 Ferndale Road, Northville, Bristol, 7.
Wolverhampton	W. T. Vaughan, "Windsor", 24 Windermere Road, Palmers Cross, Tettenhall, Staffs.
Worcester	R. Wheeler, Old Farm House, 7 Parish Hill, Bournheath, near Bromsgrove, Worcestershire.

CORRESPONDING MEMBER IN MIDDLE EAST

J. Merkine, 45 Arlozoroff Street, Ramat-Gan, Israel.

CORRESPONDING MEMBER IN RANGOON

J. T. Foster, Office of the Principal, Regional Marine Diesel Training Centre, Dalla Dockyard, Inland Water Transport Board, Phayre Street, Rangoon, Burma.

CORRESPONDING MEMBER IN WEST AFRICA

H. P. Halfter, Gold Coast Railways & Harbour Admin., P.O. Box 202, Takoradi, Ghana, West Africa.

GRADUATE SECTION HONORARY SECRETARIES

Birmingham	J. R. Brownsword, 202 Buryfield Road, Solihull, Warwickshire.
Coventry	E. R. S. Marrs, 15 Montrose Avenue, Lillington, Leamington Spa.
Leeds	B. Noble, 8 Springwell View, Birstall, near Leeds.
Liverpool	J. R. Jones, 9 Beaumaris Drive, Thingwall, Wirral.
London	B. W. Jenney, 58 Langdale Gardens, Perivale, Middlesex.
Luton	D. A. Slough, 41 Felix Avenue, Luton, Bedfordshire.
Manchester	R. Whitehead, 60 Travis Street, Hyde, Cheshire.
Newcastle upon Tyne ...	M. Dewhurst, 6 Gerrard Road, Whitley Bay, Northumberland.
Rochester & District ...	D. M. Samson, 123 York Road, Maidstone, Kent.
Sheffield	P. Brown, 21 Rowan Tree Dell, Totley, Sheffield.
Western	R. E. Everhard, 25 Boverton Road, Filton, Bristol.
Wolverhampton	I. R. Jones, "Shalimar", Clive Road, Pattingham, Wolverhampton, Staffordshire.

LOUGHBOROUGH COLLEGE STUDENT SECTION

Chairman:
A. Roberts, 32 Duncan Road, Aylestone, Leicester.

Honorary Secretary:
J Fairbrother, Dept. of Industrial Engineering, College of Technology, Loughborough, Leics

MATERIALS HANDLING GROUP

Chairman:
F. E. Rattlidge, Evered & Company Ltd., Smethwick, 40, Staffordshire.

Secretary:
I. B. King, Assistant Education and Technical Officer, 10 Chesterfield Street, London, W.1.

EDUCATION DISCUSSION GROUPS

London Centre

Chairman:
C. C. Spanswick, 24 Mill Drive, Hove, 4, Sussex.

Honorary Secretary:
D. R. C. Holmes, 35 Sandringham Drive, Ashford, Middlesex.

Midland Centre

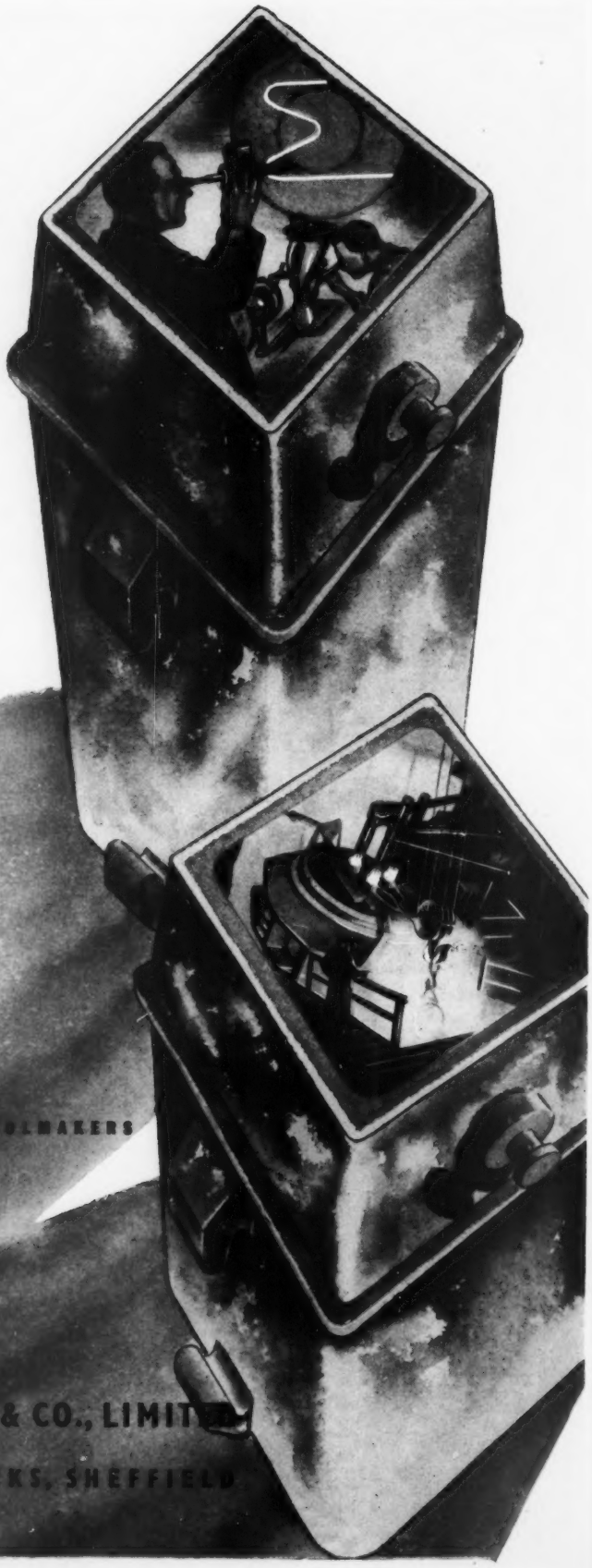
Chairman:
W. L. Jackson, Senior Lecturer in Production Engineering, Chance Technical College, Smethwick.

Honorary Secretary:
N. Ward, 88 Sutton Oak Road, Streetly, Sutton Coldfield.

Mobil Cutting Oils
SPEED PRODUCTION
Machine tool operation is daily becoming more complex . . . more difficult. Industrial speed-up and continuous production depend on cutting oils designed to fit each individual job.
Today Mobil Cutting Oils make hundreds of difficult cutting jobs possible.
These special oils are helping to increase the efficiency of machining operations everywhere.
Mobil

IN EVERY INGOT . . .

. . . cast from the furnaces of the *Osborn* group of Companies, cumulative experience from generations of craftsmanship is combined with modern research and technology to produce steel of superlative quality. A wide range of high-speed and other special tool steels is manufactured and many other products including steel castings, forgings and engineers' cutting tools are produced within the same organisation.



STEELMAKERS
STEELFOUNDERS
ENGINEERS' TOOLMAKERS

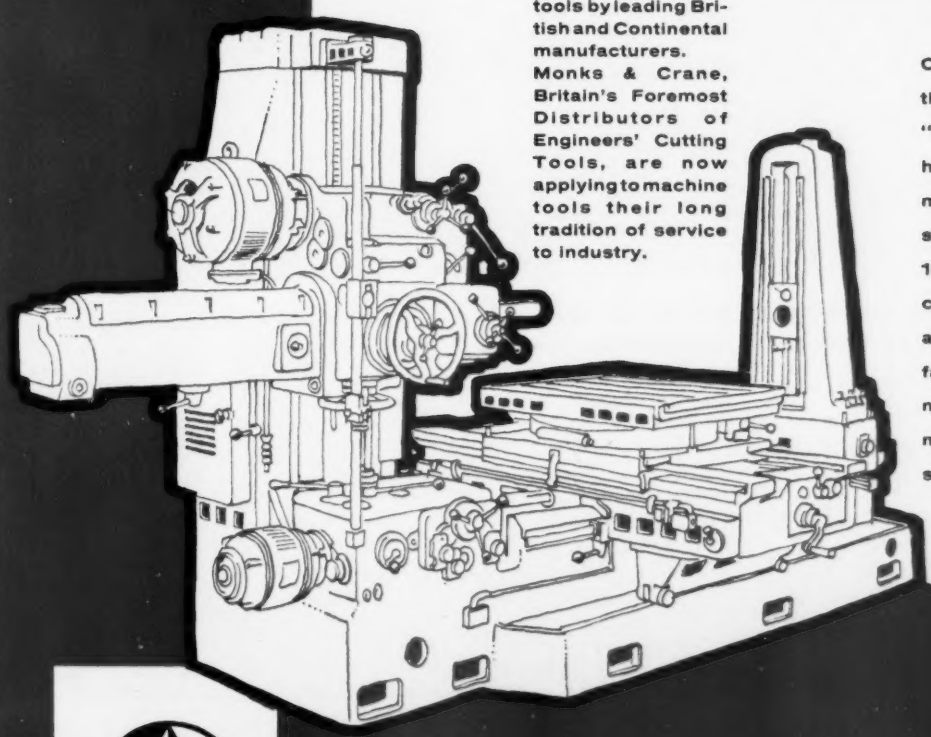
OSBORN

SAMUEL OSBORN & CO., LIMITED
CLYDE STEEL WORKS, SHEFFIELD

visit this fine new

MACHINE TOOL SHOWROOM

where you can see displayed a wide range of machine tools by leading British and Continental manufacturers. Monks & Crane, Britain's Foremost Distributors of Engineers' Cutting Tools, are now applying to machine tools their long tradition of service to industry.



Completely new to this country, the "AZETA" GL 80 horizontal boring machine with 3½" dia. spindle. Powered by 10 h.p. motor, is complete with accessories for facing, boring, vertical milling, horizontal milling and screw-cutting.

M&C

Monks & Crane Ltd

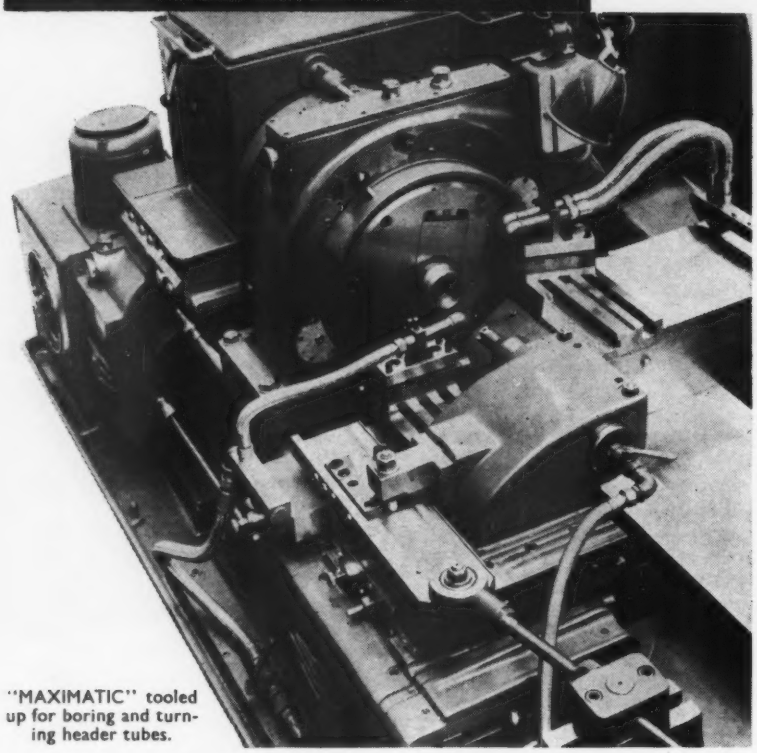
MACHINE TOOL DIVISION

GARRETTS GREEN LANE · BIRMINGHAM 33

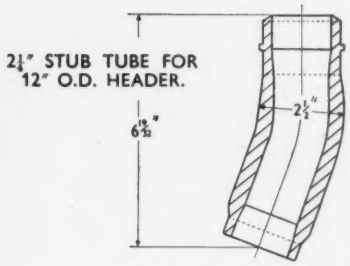
LONDON · MANCHESTER · GLASGOW · NEWCASTLE-ON-TYNE · LEEDS · BRISTOL

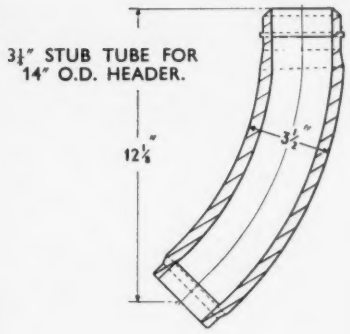
MAXIMATIC
AUTOMATIC MULTI-TOOL LATHES

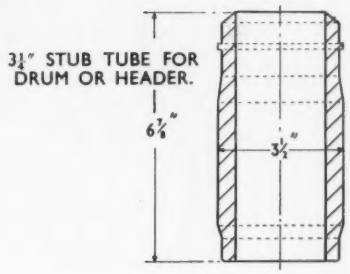
The modern, fast way of BORING & TURNING HEADER TUBES



"MAXIMATIC" tooled up for boring and turning header tubes.

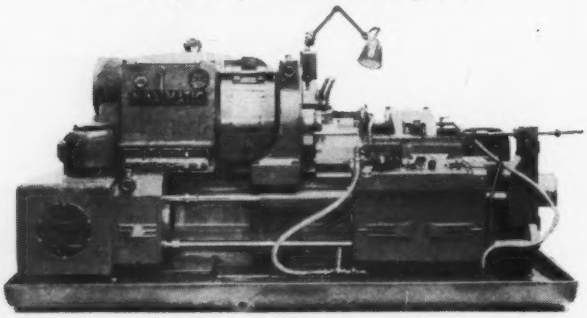


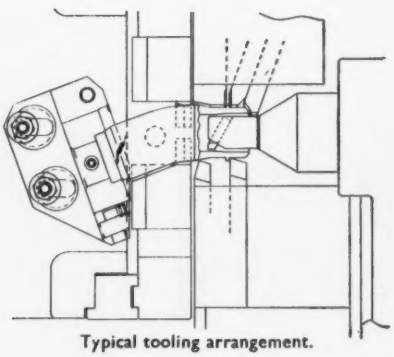




Drummond Maximatics provide a fast, accurate method of machining components required in considerable quantities. For example, header tubes of different types, can be bored and turned in batches of 1,000 or so with considerable savings in time and cost of production. We shall be pleased to investigate similar applications and put forward suggestions for automatic machining of components perhaps not previously considered for a multi-tool lathe.

DRUMMOND BROS LTD.
GUILDFORD · ENGLAND
Member of the Asquith Machine Tool Corporation





Typical tooling arrangement.

Sales and Service for the British Isles

DRUMMOND-ASQUITH LIMITED
Member of the Asquith Machine Tool Corporation

KING EDWARD HOUSE, NEW ST., BIRMINGHAM *Phone: Midland 3431. Also at LONDON Phone: Trafalgar 7224 & GLASGOW Phone: Central 0922*

D338

Light-duty radials for fast, accurate production

The Asquith NLD machine is a high quality light duty radial designed for simplicity of operation, economy and productive efficiency. 12 spindle speeds and 4 spindle feeds are provided, alternative speed ranges being available for customers selection when ordering. Special provision is made for the supply of filtered oil to all rotating parts in the slide, including spindle bearings. Available with radius, spindle centre to pillar centre 3′ 6″, 5′ 0″, 6′ 0″, 7′ 0″ or 8′ 0″. Write today for full details.

WILLIAM ASQUITH LTD.

HALIFAX · ENGLAND

Member of the Asquith Machine Tool Corporation

Sales and Service for the British Isles

DRUMMOND-ASQUITH LIMITED

Member of the Asquith Machine Tool Corporation

KING EDWARD HOUSE, NEW ST., BIRMINGHAM *Phone: Midland 3431.* *Also at* LONDON *Phone: Trafalgar 7224 &* GLASGOW *Phone: Central 0922*

A370

DRUMMOND-ASQUITH LTD

Have pleasure in

Announcing

their appointment as Sole Distributors
throughout the world for the complete range of

SURFACE GRINDING MACHINES

BUILT BY

SNOW & CO. LTD

SHEFFIELD · ENGLAND

SURFACE SNOW GRINDERS

Manufacturers of a wide range of Precision Surface Grinding Machines, including Horizontal and Vertical Spindle Types with both reciprocating and rotary tables, Double Disc and Slideway Grinders

World Wide Distributors

DRUMMOND-ASQUITH LIMITED

KING EDWARD HOUSE, NEW ST., BIRMINGHAM *Phone: Midland 3431. Also at LONDON Phone: Trafalgar 7224 & GLASGOW Phone: Central 0922*

EXPORT DIVISION : HALIFAX HOUSE, STRAND W.C.2. *Telephone Trafalgar 7224*

er

0922

POLLARD means BEARINGS

In the great British tradition of ***quality & precision***

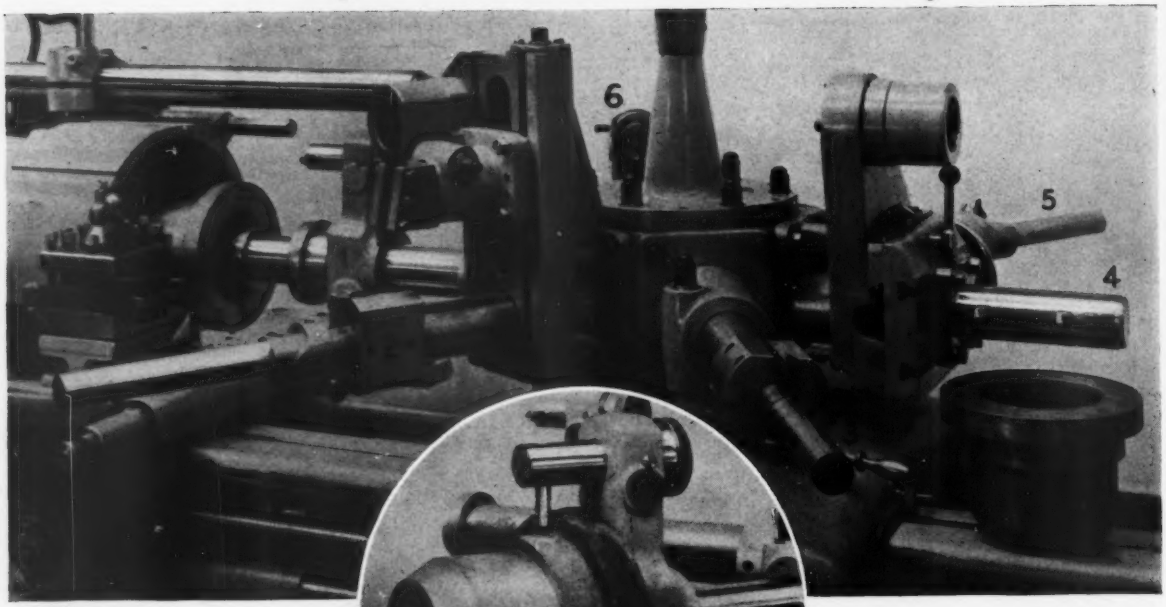
POLLARD PB BEARINGS

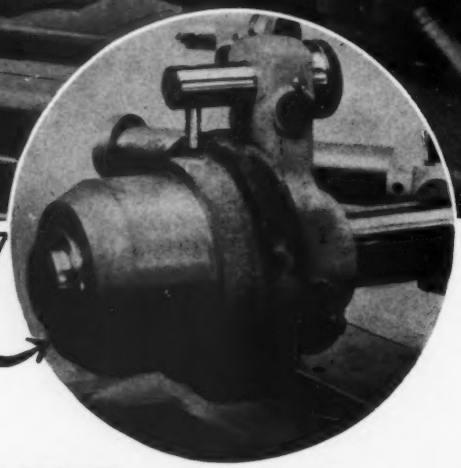
Issued by: POLLARD BALL & ROLLER BEARING CO. LTD

FERRYBRIDGE · KNOTTINGLEY · YORKSHIRE · Tel: 2323 · Telex: 55166

distribution throughout the world

Maximum Production Special Tool Layouts





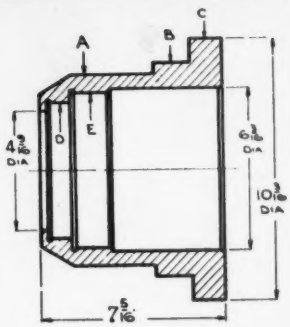
PULLEY SLEEVE

Ward

No. 8 TURRET LATHE

FITTED WITH 15in TUDOR 3-JAW CHUCK

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Chuck on A (using Loading Attachment) -	1	—	—	—	—
2. Rough Face and Rough Turn C (1st cut)	—	Front 1	85	235	48
Rough Bore $6\frac{3}{16}$ and $4\frac{9}{16}$ and Rough Turn C - - - - - - - -	2	—	85	230	70
3. Rough Bore D and E - - - - -	3	—	85	133	70
Rough Turn B and Face Back of Flange	—	Front 2	85	225	70
4. Undercut and Chamfer Bores (Recessing Toolholder) - - - - - - - -	4	—	85	133	Hand
5. Microbore D, E and $6\frac{3}{16}$ dias. - -	5	—	175	285	98
Finish Turn C - - - - - - - -	—	Front 3	175	465	70
Finish Double Face Flange - - - -	—	Front 4	175	465	70
6. Remove Part from Chuck (using Unloading Attachment) - - - - -	6	—	—	—	—



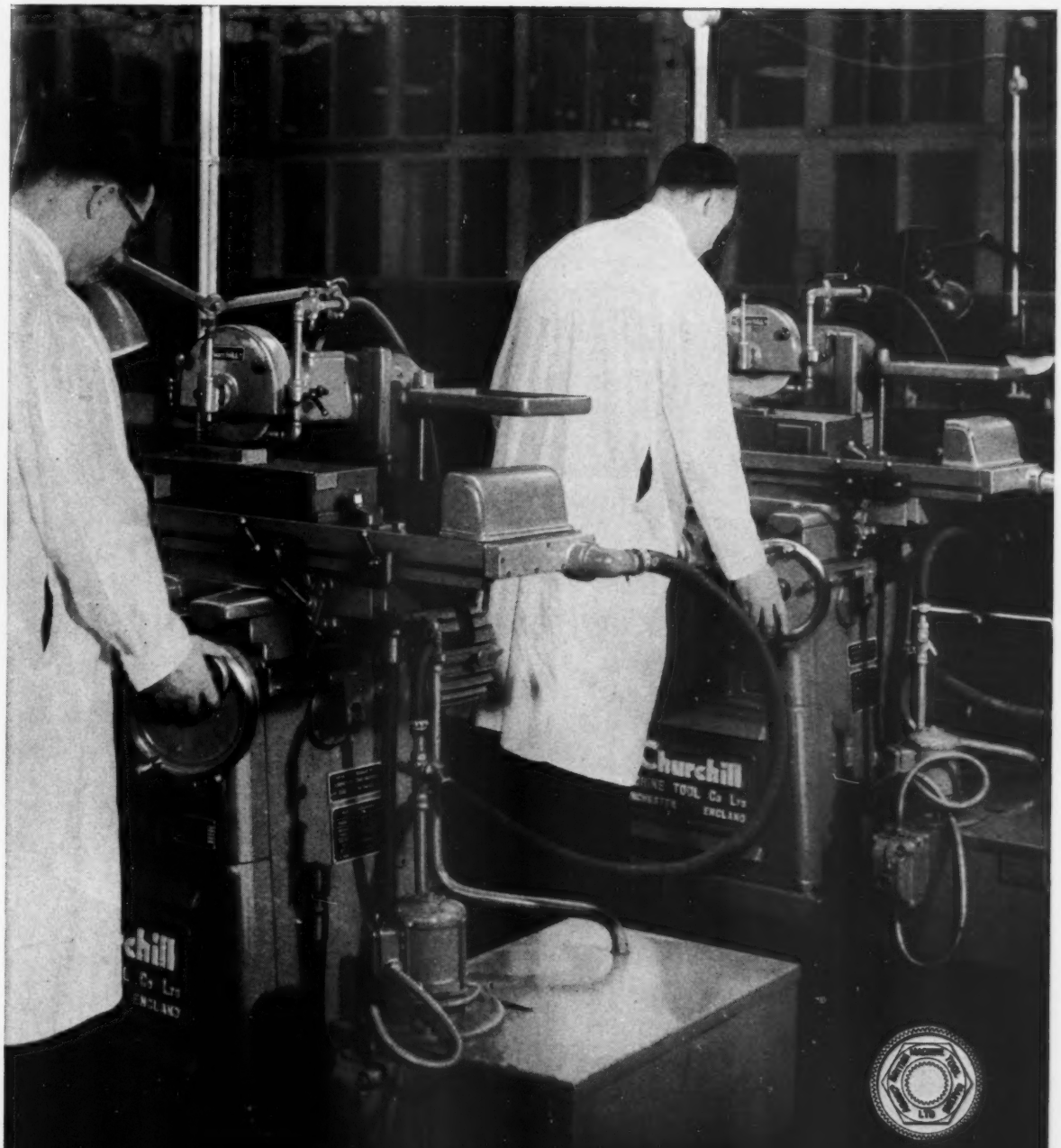
Tungsten Carbide Cutting Tools

CAST IRON CASTING

Floor-to-Floor Time:
13 mins. each.

H·W·WARD & CO LTD
SELLY OAK
BIRMINGHAM 29
TELEPHONE SELLY OAK 1131

W655



Grinding Components for Marine and Aeronautical Equipment to Fine Limits at Sperry Gyroscope Co. Ltd. on

THE CHURCHILL MACHINE TOOL
Broadheath, nr. Manchester. Co. Ltd.

Export Sales Organisation

ASSOCIATED BRITISH MACHINE TOOL MAKERS LTD.
London Branches & Agents

Home Selling Agents

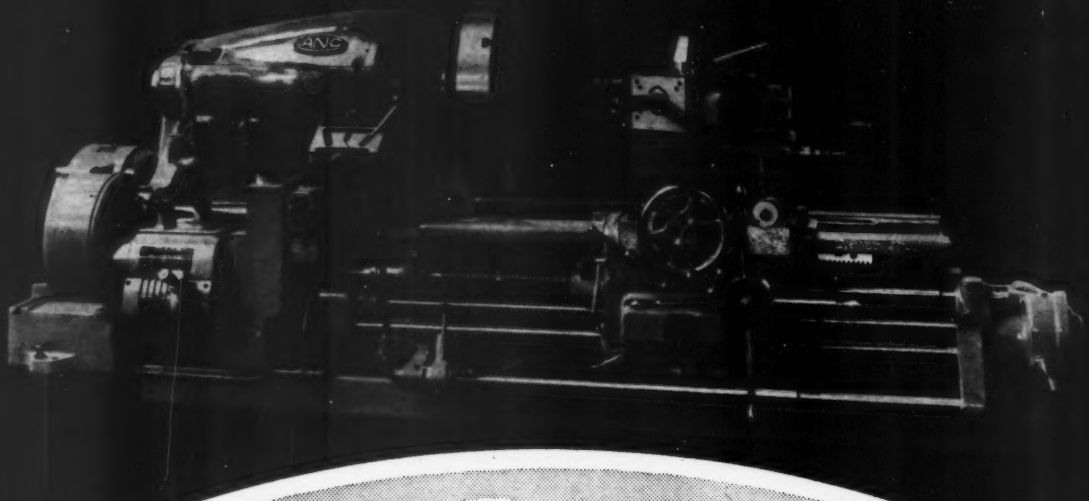
CHARLES CHURCHILL & CO. LTD.
Birmingham & Branches

Churchill

MODEL NB 18 x 6 IN.

HORIZONTAL SURFACE GRINDING MACHINES

C671-1D



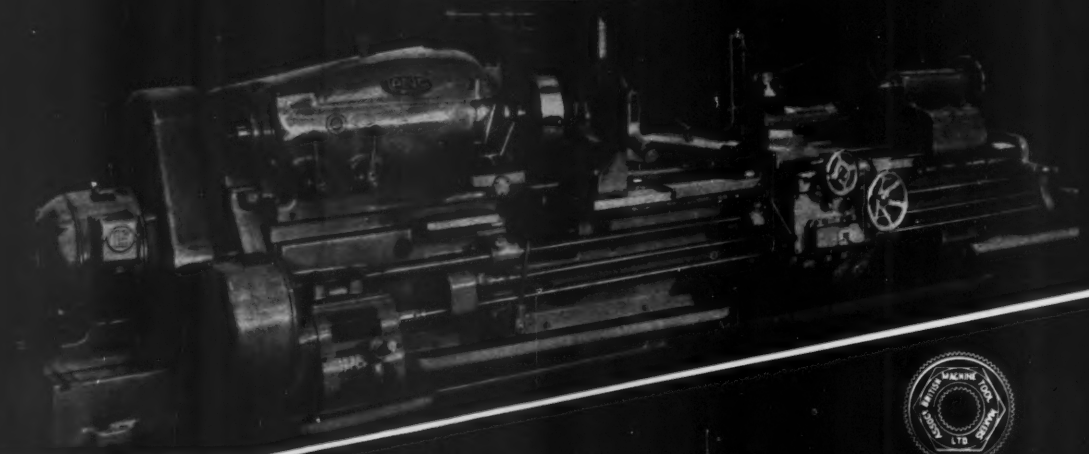
LANG

model CA4

SURFACING BORING & SCREWCUTTING LATHES. 36" & 48" SWING.

SLIDING SURFACING & SCREWCUTTING LATHES. 24" TO 36" SWING.

model A4



JOHN LANG & SONS LTD.

JOHNSTONE — RENFREWSHIRE

Telephone: Johnstone 400

Telegrams: "Lang Johnstone"

LONDON OFFICE:
ASSOCIATED BRITISH MACHINE TOOL MAKERS LTD.
17, GROSVENOR GARDENS, SW1

L215E3

THE SOUND APPROACH TO QUIET!

. . . install clean, streamlined N.S.E. Partitioning, establish a happy congenial atmosphere and increase staff efficiency.

EASY TO ERECT
ADAPTABLE
ECONOMICAL

FOR OFFICE AND FACTORY

...it must be

NSE

STEEL PARTITIONING

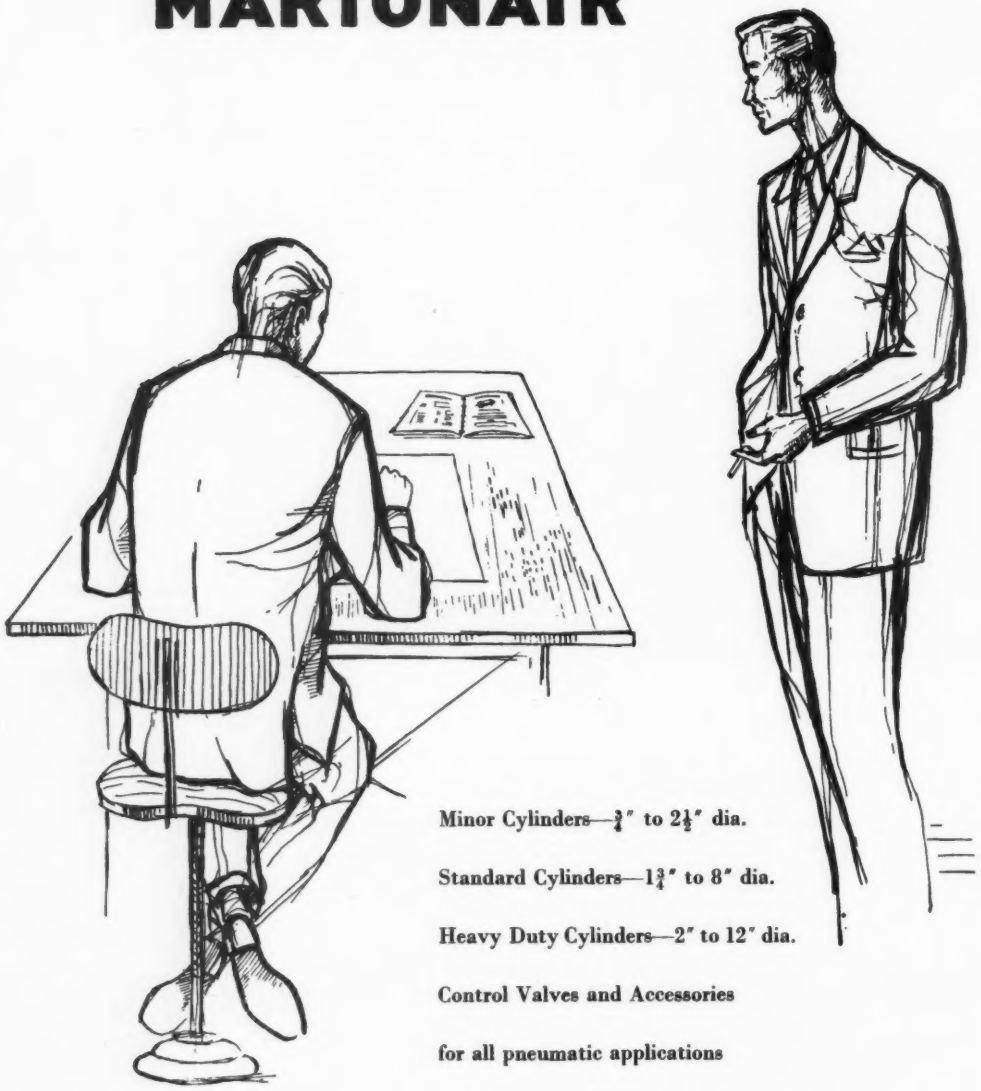
Inspect the full range of N.S.E. Partitioning and Office Equipment at our modern Showrooms in
BRISTOL, BIRMINGHAM, MANCHESTER
or visit our London Display Centre
149 BOROUGH HIGH STREET, S.E.1

Send TO-DAY for our NEW FREE fully illustrated 36 page catalogue

NORWOOD STEEL EQUIPMENT LTD., HARLOW, ESSEX. TEL: HARLOW 25651

Specify...

MARTONAIR



Minor Cylinders—$\frac{3}{4}$″ to 2$\frac{1}{2}$″ dia.

Standard Cylinders—1$\frac{3}{4}$″ to 8″ dia.

Heavy Duty Cylinders—2″ to 12″ dia.

Control Valves and Accessories

for all pneumatic applications

Catalogue on application to:

MARTONAIR LTD · PARKSHOT · RICHMOND · SURREY

Also in Australia, Belgium, Canada, Denmark, Finland, France, Germany, Holland, Italy, New Zealand, Norway, South Africa, Spain, Sweden, Switzerland, U.S.A.

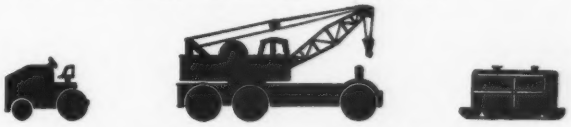
A.D.43

POWER for industry

Our range of industrial engines are a practical proposition for many types of industrial equipment **. . . compressors, cranes, pumps, contractor equipment, earth borers, generators, railcars, welding plant, works trucks, tractors and conversions.** Simple design, modern flow-line production methods and common interchangeable parts contribute to the low cost of these high efficiency engines. And remember, every engine is fully backed by a World-wide Parts and Service Organisation. Take your choice from a wide power range . . . Diesel 20 to 86 b.h.p. and Petrol 11 to 87 b.h.p. (12-hr. rating).

DIESEL ECONOMY

— have you considered the replacement of existing power units in your equipment and trucks with the famous 4D Diesel engine? You'll have the unique advantages of economy, long-life and low running costs . . . plus the best service in the World!



Wherever you are, whatever your problem,

FORD

MOTOR COMPANY LIMITED · ENGLAND

are at your service

For further details of our

INDUSTRIAL ENGINES

and the equipment they power, send the coupon to your nearest Ford Dealer or direct to

Please send me technical brochures of your *PETROL/DIESEL Industrial Engines. The maximum B.H.P. required is ..... at ..... R.P.M. Also, please send details of the following equipment powered by your engines.

.....

.....

Name .....

Address .....

.....

Nature of Business .....

..... **Telephone No.** .....

* *Delete where not applicable*

G51·20·4

FORD MOTOR COMPANY LIMITED · PARTS DIVISION (G51) · AVELEY DEPOT · SOUTH OCKENDON · ROMFORD · ESSEX · ENGLAND

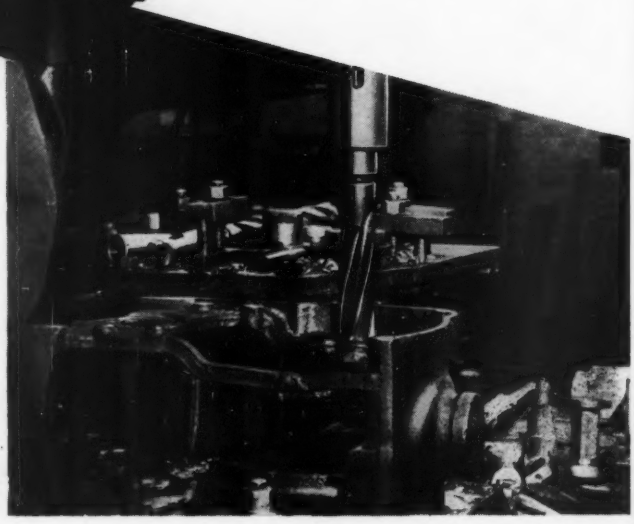
ARCHDALE

MEDIUM DUTY HIGH SPEED RADIALS

Assure high drilling rates at YALE & TOWNE

Because of their wide speed and feed range, simplicity of control and high penetration rates, ARCHDALE high speed radials assure maximum output in this and many other factories.
Sizes range from 4 ft. to 7 ft. radius for drilling up to 2 in. diameter in mild steel.

N.B. Our illustration shows a 5 ft. machine drilling handle attachment holes 1.37/64 in. diameter in driver gear housing for light overhead cranes.



Photographs by courtesy of the YALE & TOWNE Manufacturing Co. Materials Handling Division, Wednesfield, Staffs. Manufacturers of YALE Materials Handling Equipment

JAMES ARCHDALE & CO. LTD.

Registered Office: Ledsam Street, Birmingham 16
Telephone: EDGbaston 2276

Works: Blackpole Works, Worcester
Telephone: Worcester 27081 (6 lines)

A member of the Staveley Coal & Iron Co. Ltd., Group

Sole Selling Agents:
ALFRED HERBERT LTD., COVENTRY. *Telephone: Coventry 89221*

Regentone chose MAXAM Fluid Power operated Rotasembler dispensing machines to obtain a 40% increase in assembly efficiency

Work Study Equipments of Woodford developed and manufacture Rotasemblers, the new rotary-indexing storage and dispensing machines which have made their first appearance at Regentone Radio and Television Ltd. Twenty Rotasemblers have been installed to store and dispense small electrical components for the production of printed circuit radio and television receivers.

The indexing mechanism which turns the Rotasembler is operated by a MAXAM double-acting air cylinder and an automatic brake assembly. A MAXAM foot-valve controls the movements of the air cylinder and the brake which, in turn, controls indexing movements of the storage hoppers.

These movements bring the components, in correct assembly sequence, to a point only a few inches from the assembly area and simplify identification of parts. Assembly errors are almost entirely eliminated.

More and more constructors of flow production machinery are designing their assemblies with MAXAM Fluid Power in mind!

If you are a Chief Draughtsman, Works Manager, Production Head or other person seriously interested in safely increasing productivity, please send for our literature covering standard valves, cylinders, rams and other hydraulic/pneumatic equipment in a wide range of sizes and types.

MAXAM POWER LIMITED

Distributed by:

Holman Bros. Limited, Camborne, England; Camborne 2275 and at 44 Brook Street, London W.1; Hyde Park 9444.

Also in Birmingham · Cardiff · Glasgow · Peterborough Sheffield. Australia · Canada · East Africa · France India · South Africa · Spain · U.S.A. · West Africa.

With Agents and Representatives throughout the world.

THE HOLMAN GROUP

MAXAM

REGISTERED TRADE MARK

Fluid Power Equipment

MA11

You could save up to £3,000 p.a. using

AZOFLEX FB Intense-line Paper in a

Model 150 AZOFLEX Copying Machine

Azoflex equipment will be demonstrated on
STAND V10
ELECTRICAL ENGINEERS EXHIBITION
EARLS COURT APRIL 5-9

AZOFLEX is the word for fast, economical copying. Using AZOFLEX FB intense-line paper, you can get 10,000 copies of invoices, documents, parts-lists, etc., every working day from the Model 150 AZOFLEX combined automatic printer/developer. Consider these major economies:

1
AZOFLEX FB dyeline paper supplied in rolls is $\frac{2}{3}$ cheaper than cut sheets. SAVING: approximately £1,800 per annum on output of 10,000 (13″ × 8″) dyeline prints per day.

2
Output of only one Model 150 with one operator is the equivalent of four machines hand-fed by four operators. SAVING: approximately £1,100.

N.B. Many business and industrial concerns find that it pays them to hire certain AZOFLEX dyeline machines, rather than buy them outright. Alternatively, rental purchase may be preferred.
May we send a representative to discuss in confidence the most beneficial terms for your company?

Even if your requirements are only 5,000 copies a day, your total annual saving can amount to £1,000 per annum, and leave your AZOFLEX operator time for other duties. AZOFLEX dyeline copying saves time, saves space, saves staff, and saves real money.

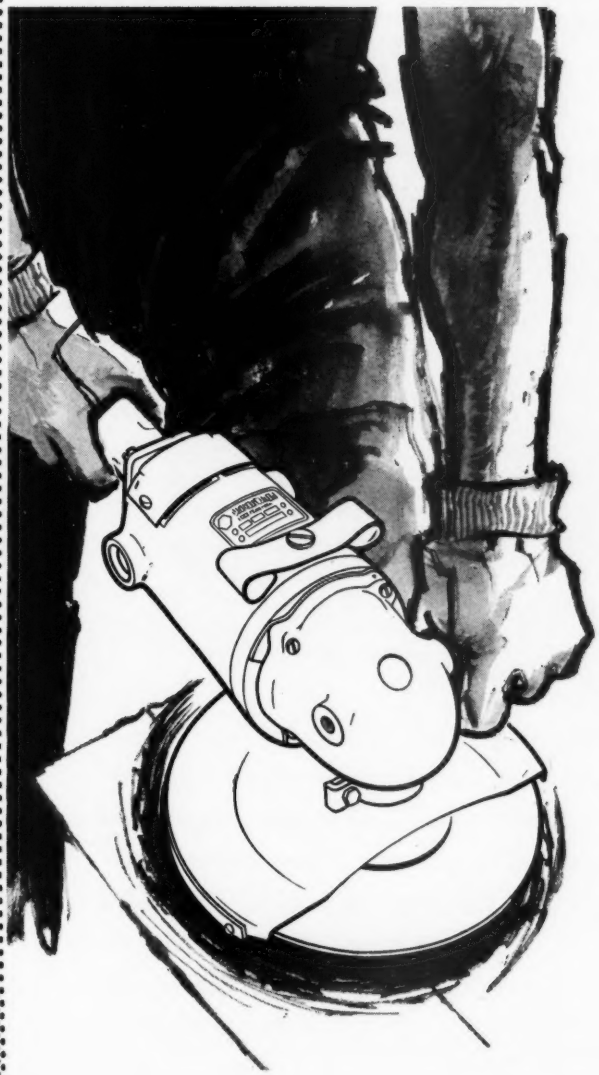
ILFORD *Azoflex*

PHOTOCOPYING PAPERS & MACHINES

ILFORD LIMITED, INDUSTRIAL SALES DEPT. AZ21M, ILFORD, ESSEX. TELEPHONE: ILFORD 3000

Black & Decker

A Grinder with Guts



For years W. Flanagan & Son of Liverpool searched for a portable grinder capable of standing up to continuous heavy duty work in their sheet metal shop.

Black & Decker provided the complete answer with their new Heavy Duty Angle Grinder. Here, at last, is "A grinder with guts" taking every heavy duty grinding operation in its stride. Long after former machines would have broken down Black & Decker Grinders are still on the job. Service costs are slashed to a minimum, needless production delays eliminated.

Flanagan's say "All future orders for Angle Grinders, of which we are exceptionally large users, will be forwarded to you without hesitation".

12 MONTHS FREE SERVICE FROM DATE OF PURCHASE

Black & Decker's confidence in their new Angle Grinder is backed-up by this positive guarantee of quality and performance. No other electric tool manufacturer can match this unique offer.

DEPRESSED CENTRE DISCS. Speed weld dressing—speed edge preparation for welding—speed grinding off flame cut edges.

CUT OFF WHEELS. For removing casting risers—cutting off angle iron, bolts, steel rods, etc.

Attachments also available for wire brushing, sanding, planing.

BLACK & DECKER 50th YEAR POWER TOOLS

POST NOW FOR FULL INFORMATION OR 14 DAYS FREE TRIAL

BLACK & DECKER LIMITED

HARMONDSWORTH MIDDLESEX

Please send more information on your Angle Grinders ☐

Please arrange a 14 days free trial (without obligation) ☐

(Tick where necessary)

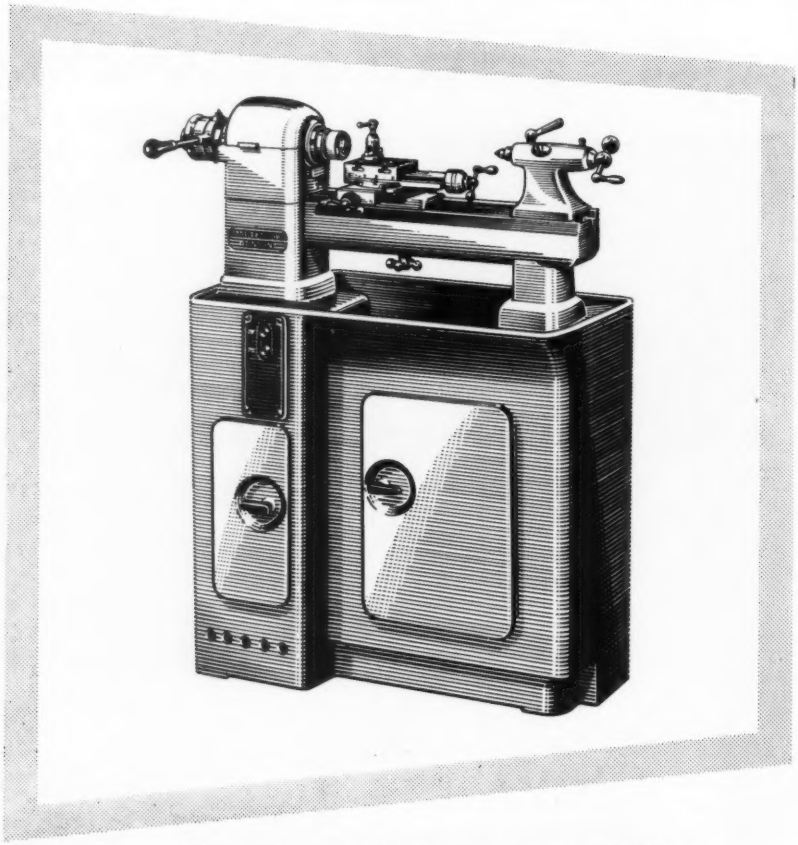
NAME .....

COMPANY .....

ADDRESS .....

IPE 2

Precision Lathes....



the **SMART & BROWN**

SERIES L LATHES

Numerous combinations can be obtained with standard attachments. Direct motor and countershaft drives can be furnished.

EPICYCLIC GEARBOX

is now available, giving a wider range of spindle speeds.

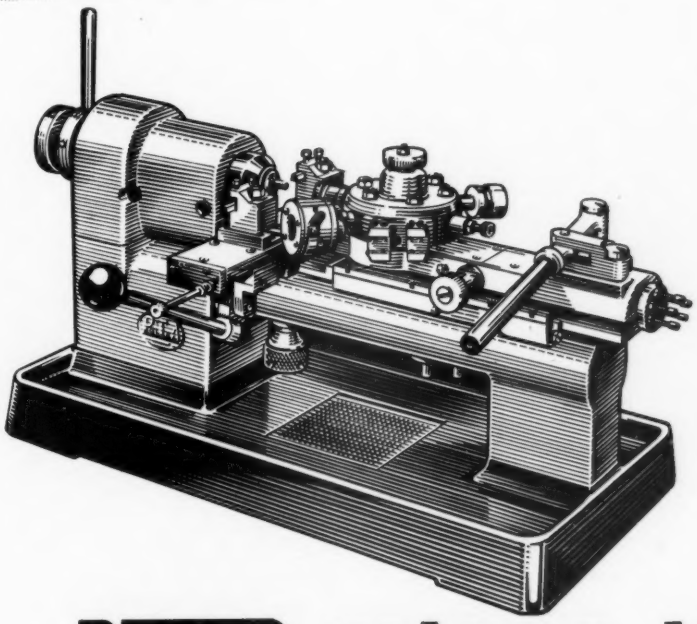
ONE OF BRITAIN'S FINE LATHES – *Designed for the operator*

S&B

Smart & Brown

25 MANCHESTER SQUARE · LONDON · W.1

from Smart & Brown



PULTRA micro lathes

The Pultra Capstan Lathe illustrated
is available in 50, 70 and 90mm.
centre heights and can also be supplied
as Toolroom, General Purpose and
Production models.
Lathes can be equipped to your
requirements from the standard units.

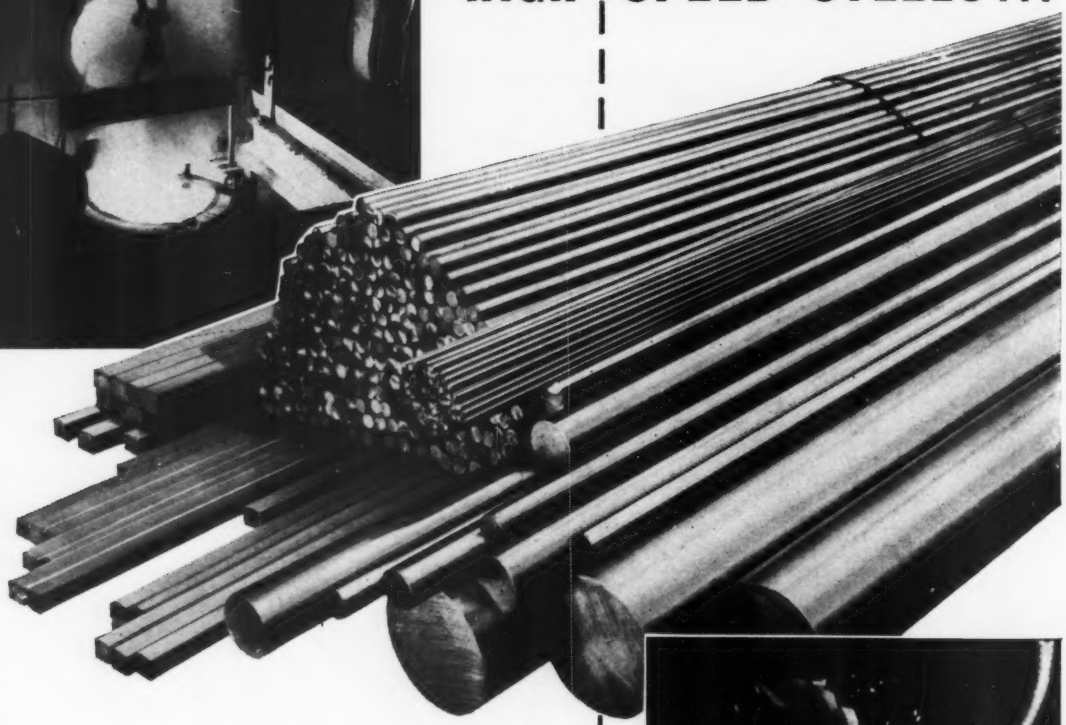
INTERNATIONAL MACHINE TOOL EXHIBITION 1960
Olympia, London June 25-July 8
STAND No. 306
GRAND HALL GALLERY

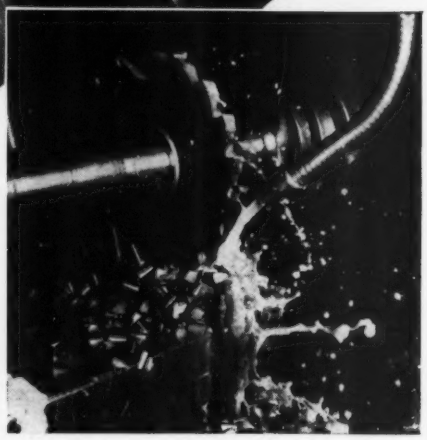
(machine tools) Ltd.

Telephone WELbeck 7941-6 Cables Smartool, Wesdo, London.
MAKERS OF PULTRA MICRO LATHES AND GRINDING MACHINES
Member of the GAS PURIFICATION AND CHEMICAL GROUP OF COMPANIES

NRP 3157

SPEEDICUT
HIGH SPEED STEELS...





...for all cutting tools

The high production rates achieved in cutting both soft and hard materials in the modern machine shop are in a large measure attributable to the efficient use of high speed steel tools.

Firth Brown high speed steels are distinguished among tool materials by their ability to develop by appropriate heat treatment an outstanding combination of the principal characteristics required in cutting tools, namely hot hardness, wear resistance and toughness, enabling them to retain their cutting ability at speeds, feeds and depths of cut.

There is a Firth Brown high speed steel for your every need — write for Publication No. 224 (Section 7) for further details.

by

FIRTH BROWN

ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

THOS FIRTH & JOHN BROWN LIMITED · SHEFFIELD · ENGLAND

THE EVENT WHICH NO INDUSTRIALIST,
ENGINEER OR PRODUCTION EXECUTIVE SHOULD MISS!

EARLS COURT 3-13 MAY

mechanical handling exhibition

THE WORLD'S LARGEST DISPLAY OF LABOUR-SAVING EQUIPMENT

This will be the greatest-ever exhibition of equipment and machinery for saving time and effort. Exhibits in over half-a-million square feet of space will range from complete handling systems for large-scale factory layouts to aerial ropeways, electronic control equipment, cranes, conveyors, trucks and lifting tackle, with experts at hand to discuss your individual problems. Whether your organisation is large or small, a visit to this outstanding industrial event can result in the achievement of higher output—at reduced cost. The ticket below will admit you to the biggest exhibition of its kind the world has ever seen.

ORGANISED BY **MECHANICAL HANDLING** AN ILIFFE JOURNAL

complete and retain this free admission ticket

For additional tickets please apply to:
EXHIBITION MANAGER MECHANICAL HANDLING
DORSET HOUSE STAMFORD STREET LONDON SE1

MECHANICAL HANDLING EXHIBITION
EARLS COURT 3-13 MAY 1960
DAILY 10 A.M. - 6 P.M. *(except Sunday 8 May)*

admit one

Not valid until the details below have been completed

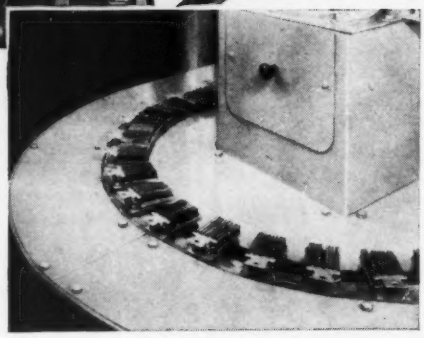
NAME .....

FIRM .....

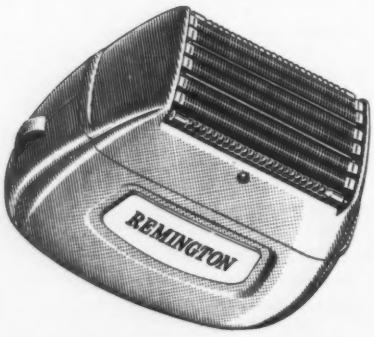
ADDRESS .....

68B

Right on the chin!



Washing THE NEW REMINGTON ELECTRIC SHAVER HEADS prior to plating



Immediately prior to plating, the New Remington shaver heads are passed through this Dawson machine to remove lapping compound. They are subjected to intense prolonged jetting treatment to bring them to the highest possible standard of cleanliness followed by a hot air drying treatment. 40,000 shaver heads are handled on each machine in an eight hour day.

This is just one more example of the vast range of jobs tackled by Dawson equipment. So whatever your metal cleaning problem get in touch with Drummond-Asquith Limited at the address below and we will endeavour to arrive at a solution both efficient and economical.

Dawson DEGREASING AND CLEANING PLANT

Sole Distributors
DRUMMOND – ASQUITH LTD.
King Edward House, New St. Birmingham
Tel. Midland 3431

Manufacturers:
DAWSON BROS. LTD., Gomersal, Near Leeds. Tel.: Cleckheaton 3422 (5 lines)
LONDON WORKS, 406 Roding Lane South, Woodford Green, Essex. Tel.: Crescent 7777 (4 lines)

A NEW SMALL GRINDER FROM ATLAS COPCO

WITH SPEED GOVERNOR ENSURING SUSTAINED MAXIMUM POWER

Designed principally for use with tungsten carbide cutters, the LSF 12 is a small, high-speed rotary grinder with a new vane-type air motor. Powerful in relation to its size and air consumption, this motor enables the LSF 12 to be used for jobs normally requiring larger, heavier tools. The centrifugal governor keeps speed constant, ensuring that maximum power is maintained.

Operating with a minimum of noise in spite of its high working speed (27,000 r.p.m.), the LSF 12 is light and convenient to handle. Refinements include:

- **Collet spindle with precision-made chuck.**
- **Air exhaust directed towards the spindle — to cool the cutters and blow away chips.**
- **Safety-type lever throttle.**
- **Special spindle ball bearings (standard size) enclosed in a steel housing.**
- **Low weight—1¼ lbs.**

Sandvik Coromant cutters for the best results

Perfectly suitable for grinding and cutting work in general, the LSF 12 is used to the best advantage with Sandvik Coromant tungsten carbide cutters. These cutters give the grinder a wide range of application including: trimming and deburring in mass production work, and the finishing of dies and jigs in tool rooms.

A complete range of compressed air equipment

Atlas Copco manufacture portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. These are sold and serviced by companies or agents in ninety countries throughout the world.

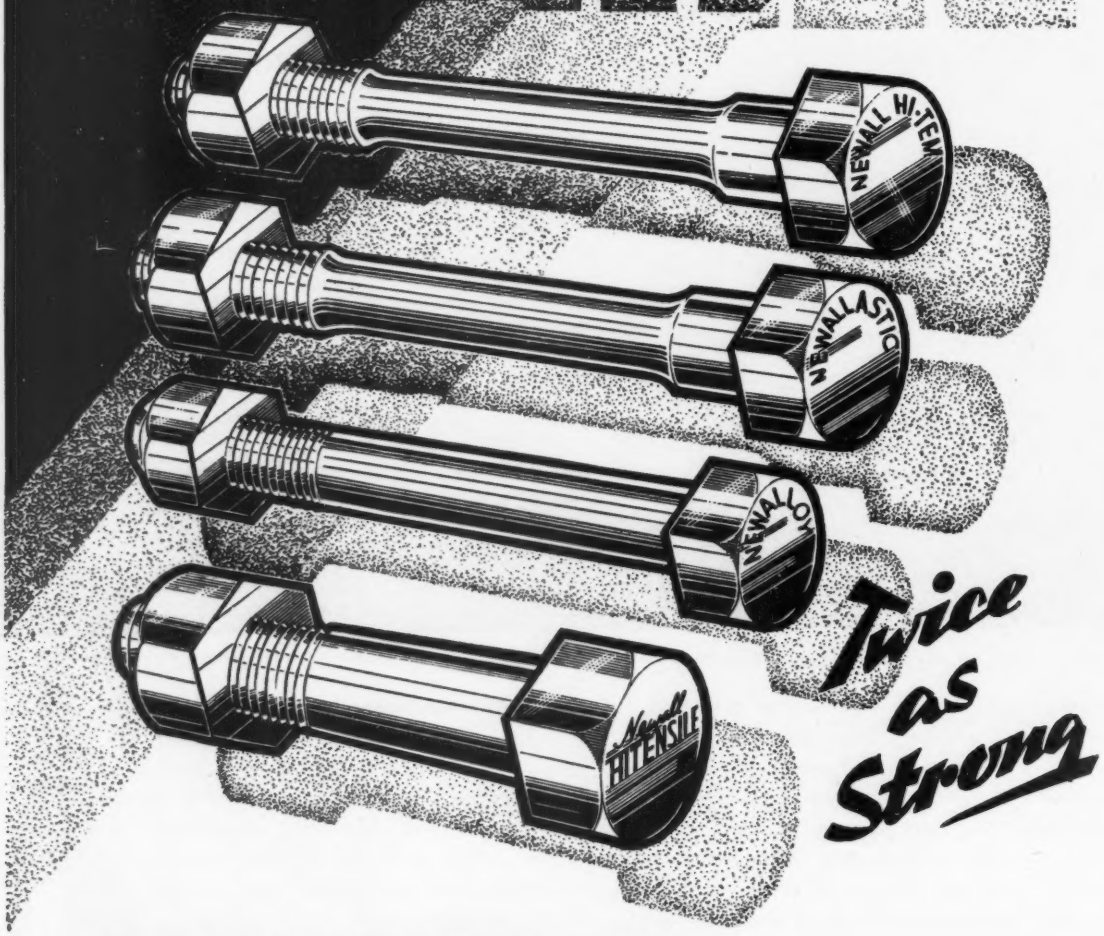
Atlas Copco
COMPRESSED AIR ENGINEERS

ATLAS COPCO (GREAT BRITAIN) LTD.

Maylands Avenue, Hemel Hempstead, Herts · *Telephone:* Boxmoor 6040

Sales and Service Depots at: LONDON · BRISTOL · CARDIFF · MANCHESTER · WALSALL · LEEDS · GLASGOW · BELFAST · DUBLIN

NEWALL



Twice as Strong

NEWALL BRANDED BOLTS

Newall Hitensile . . . Newalloy . . . Newallastic . . . Newall Hi-tem . . .

are recognised by engineers as having unique qualities. We shall be happy to supply any engineer designer who is interested with details of the various bolts and studs, which cover the full range of modern requirements.

A.P. NEWALL & CO., LTD. POSSILPARK GLASGOW N2

RF2/2 Induction Heating Unit 1·5 kW

ANOTHER NEW INDUCTION HEATER FROM PROCESS HEATING

This small equipment has a nominal output of 1.5 kW, being designed for continuous operation and works at a frequency of 2 Mc/s. It can be used for hard and soft soldering, brazing, hardening and tempering of small components. It is medium impedance, taking multi-turn work coils.

The size of the equipment is such that it will easily stand on a bench and due to its simplicity can be operated with ease by unskilled labour, enabling production cost to be reduced to a minimum.

The latest techniques have been used in its construction, enabling a quality equipment to be made in a small size without loss of reliability.

PROCESS HEATING

Free Technical Advice is offered on the applications of R.F. heating to Tempering, Brazing and Hardening processes etc. Ask our appointed agents for details of this and our other equipments or send the coupon.

To Pye Ltd. Process Heating Division, 28 James Street, Cambridge. P.E.J.4

Please send me details of Pye Process Heating Equipment

NAME .....

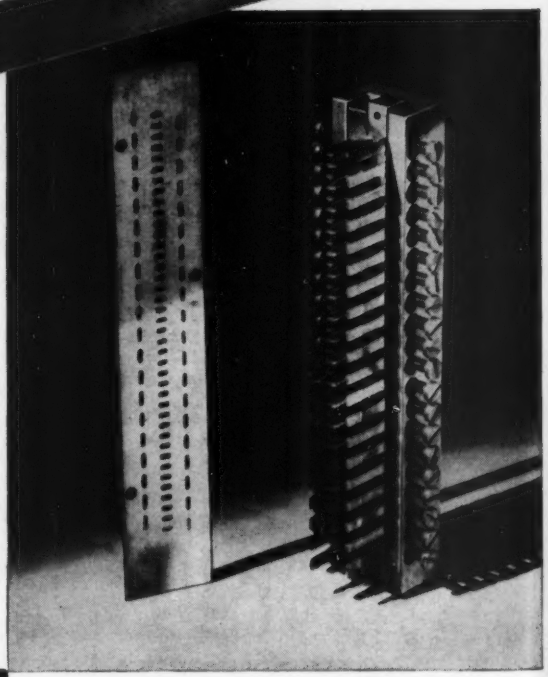
COMPANY .....

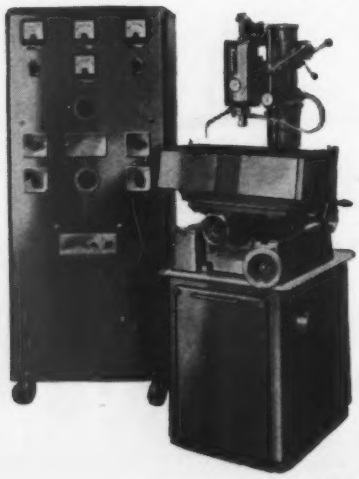
ADDRESS .....

PYE LIMITED PROCESS HEATING DIVISION Telephone: CAMBRIDGE 57590

SPARK MACHINED from the SOLID

Illustrating two distinct types of electrode. (*Above*) a solid, shaped, electrode, and (*Right*) an electrode built up from a number of separate units.



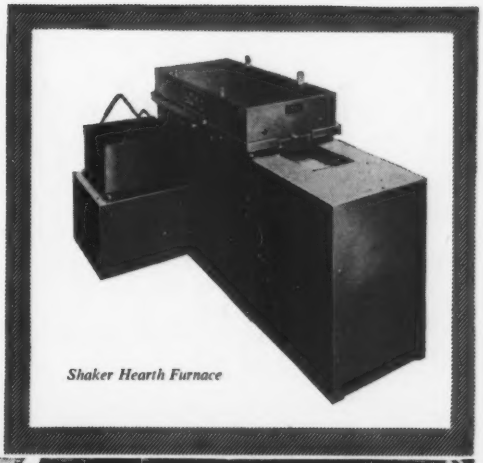


IDP SPARCATRON

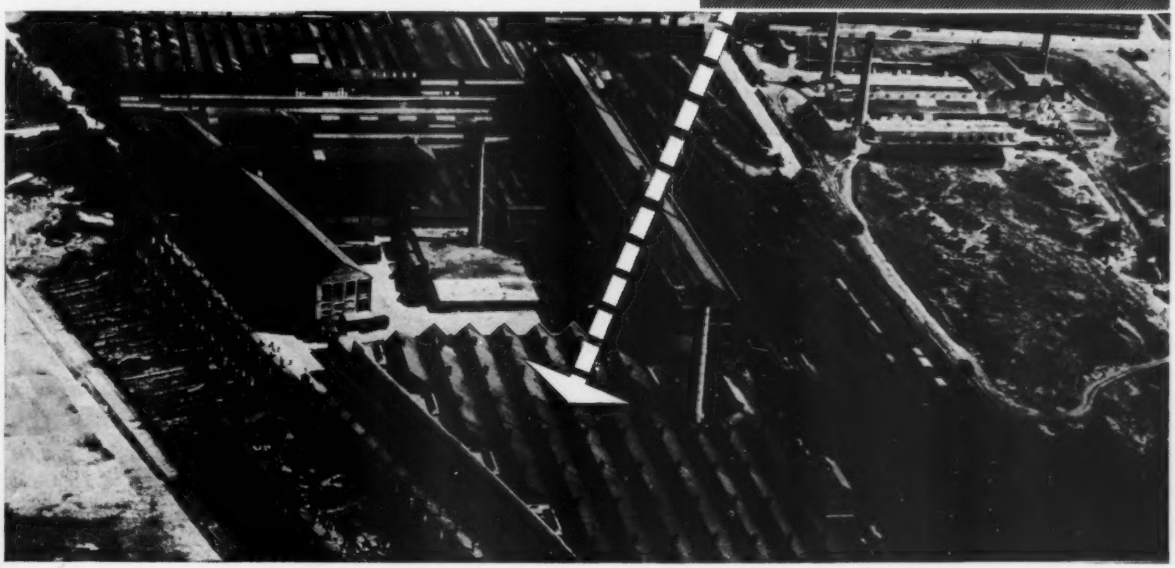
IMPREGNATED DIAMOND PRODUCTS LTD · OF GLOUCESTER · ENGLAND

Sole Agents for the United Kingdom · BURTON GRIFFITHS & CO. LTD · KITTS GREEN · BIRMINGHAM 33

Fit Wild-Barfield furnaces into *your* production line



Shaker Hearth Furnace



A Wild-Barfield furnace will bring immediate advantages. It speeds up production and helps to cut costs by eliminating delays and wasteful handling. Built to the highest standards of workmanship, these furnaces offer consistent results and minimum maintenance. The Wild-Barfield Research Department is available at all times to advise you on your heat-treatment problems.

Continuous and batch type furnaces for :

NORMALISING
HARDENING
TEMPERING
GAS CARBURISING
CARBONITRIDING
BRIGHT ANNEALING
and other applications

ELECTRIC WILD BARFIELD FURNACES

FOR ALL HEAT-TREATMENT PURPOSES

WILD-BARFIELD ELECTRIC FURNACES LIMITED

ELECFURN WORKS, OTTERSPOOL WAY, WATFORD BY-PASS, WATFORD, HERTS. Telephone: Watford 28091 (8 lines)

WB 61

KEARNS ELECTRONIC No. '0' planer table type horizontal boring, milling, drilling and tapping machine in the works of The British United Shoe Machinery Company Ltd., Leicester.

...horizontal boring machines by KEARNS

Electronically controlled co-ordinate setting developed by KEARNS and A.E.I. increases productivity by eliminating strain and fatigue.

Automatic positioning of loads up to 2 tons with a maintained accuracy of within ±0·0002″.

Punched cards, dials and push buttons simplify operation, make control effortless and inspire confidence.

H. W. KEARNS & CO LIMITED BROADHEATH near MANCHESTER

KSG10

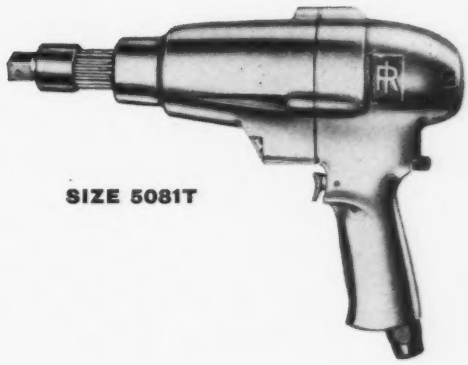
Ingersoll-Rand

air powered

Torque control Impactools

run nuts accurately and automatically to pre-set torque

SIZE 5020T



SIZE 5081T

SIZE 5040T

BRITISH MADE

NAME_____

ADDRESS_____

Ingersoll-Rand hand-held power tools are made and designed specifically for the following industries.
Please tick the industry with which you are concerned.
Descriptive literature will be mailed to you by return.

- ☐ Oil & Petroleum
- ☐ Iron & Steel
- ☐ Fabricated Metals
- ☐ Automobile
- ☐ Aircraft
- ☐ Railway
- ☐ Ship & Boat Building
- ☐ Machinery (Mechanical)
- ☐ Machinery (Electrical)
- ☐ Mining
- ☐ Public Utilities (Electricity, Gas, Water, Telephone, etc.)

Power in hand with

Ingersoll-Rand

INGERSOLL-RAND COMPANY LIMITED

165 QUEEN VICTORIA STREET LONDON EC4 • TEL: CEN 5681
Scottish Office: 20 Renfrew Street Glasgow C2
Tel: Douglas 1233 • Grams: Ingersoll Glasgow

P.3892

WE SPRING TO YOUR AID!

If you're struggling with a knotty spring or presswork problem, get on to Terrys! Our design and research staff will gladly help you out. But it's better to call us in at the very beginning . . . at the blueprint stage. Then we may save you considerable time and money. You get the full benefit of our specialised skill and experience right from the start and are sure of the most suitable springs or presswork for your particular purpose—designed for utmost efficiency and reliability. Consult us at any time—we are always at your service.

TERRYS springs and presswork

HERBERT TERRY & SONS LTD., REDDITCH, ENGLAND

℗ 18e

Testing a 40" Hypoid Gear and Pinion for a Pulper. photo by courtesy of Black Clawson International Ltd.

Spiral Bevel and Hypoid Gears from 1" to 72"

Spiral Bevel and Hypoid Gears offer many advantages for right angle drives where high efficiency smooth and silent running are required. E.N.V. specialize in the design and manufacture of straight and curved tooth bevel gears. They offer collaboration with engineers from the project stage on the design of gears and mountings. They have unique facilities for the large-scale manufacture of transmissions including final drives, differentials and axles for vehicles and agricultural equipment, precision gears for aircraft and gears for industrial applications.

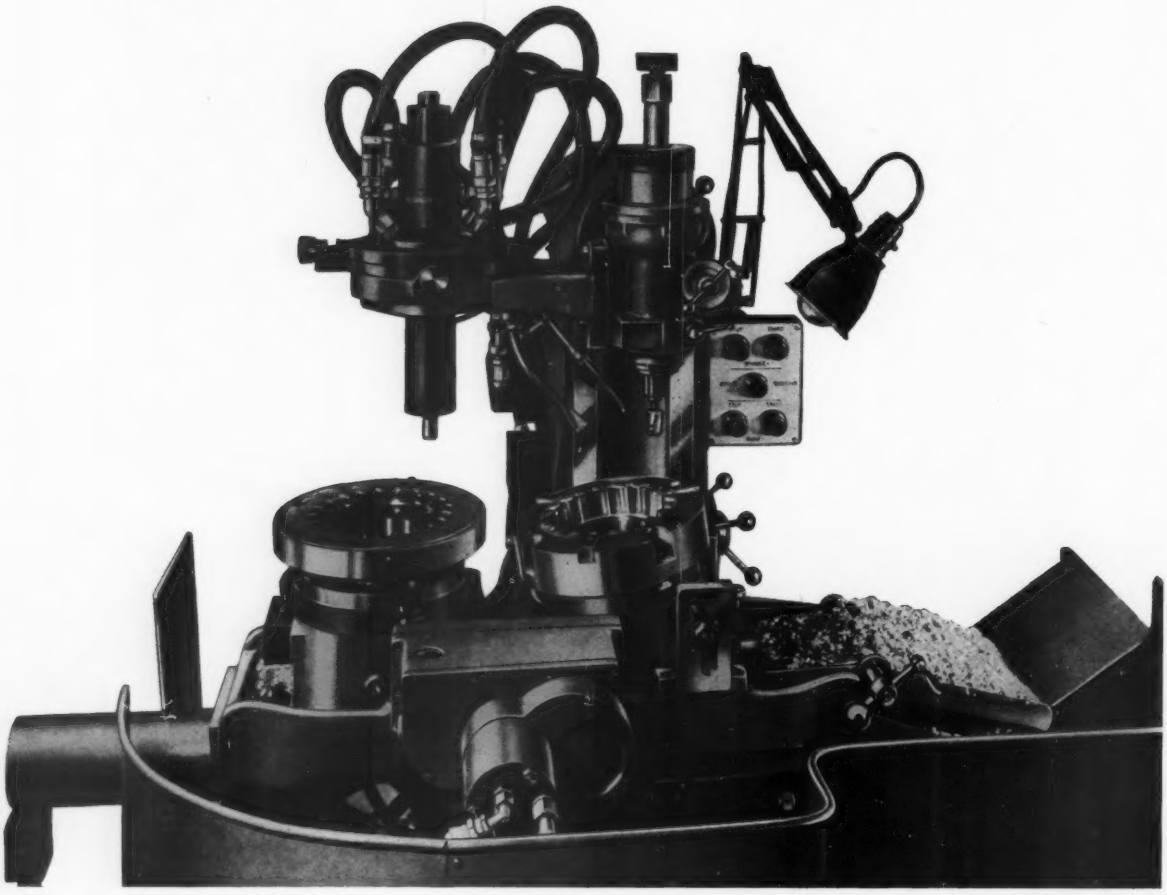
ENV *for gears*

E.N.V. ENGINEERING COMPANY LIMITED
Telephone :

HYTHE ROAD, WILLESDEN, LONDON, N.W.10
LADbroke 3622

AP 265-56

HAYES SPECIAL TRACEMASTER



FOR THE AUTOMATIC PRODUCTION OF

LIGHT ALLOY ROLLER BEARING CAGES

Photos by courtesy of GAMET PRODUCTS LTD.

HAYES ENGINEERS (LEEDS) LTD.

GELDERD ROAD, LEEDS, 12

Telephone : 30941 Grams : Toolmaker, Leeds

INTERNATIONAL MACHINE TOOL EXHIBITION 1960

Olympia · London June 25 - July 8

Sole Selling Agents for Home & Overseas :

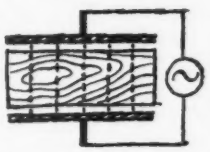
ASSOCIATED BRITISH MACHINE TOOL MAKERS LTD.

17 GROSVENOR GARDENS, LONDON, S.W.1

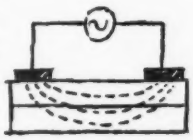
Electrical Aids in Industry *Data Sheet* **No. 10**

Dielectric Heating - 1

When an electrically non-conducting material is placed between two metal plates, called electrodes, connected to an A.C. supply, the alternating electrostatic field between the electrodes considerably speeds up the molecular movements in the material (termed a 'dielectric') as a result of which the temperature of the material under treatment rises. A similar effect is produced where the two electrodes are positioned on the same side of the dielectric; in this case the electrostatic field between them is generally known as a 'stray' or 'fringe' field.



For industrial application, the applied voltage of the order of 15,000 volts supplied by an electronic generator alternates at frequencies of some millions of cycles per second.



The amount of heat generated in the dielectric is determined by the frequency, the square of the applied voltage, the dimensions of the object and a physical property of the material termed "loss factor" and is represented by the equation:—

$$\text{Power} = 1.41\ E^2\ f.\ F\ \frac{A}{t} \times 10^{-15} \text{ kilowatts.}$$

Where E = applied voltage, f = frequency, F = loss factor.

A = area of the dielectric in square inches.

t = thickness of the dielectric in inches.

F, the loss factor, is itself equal to the expression K Cos Ø in which:
K = the dielectric constant, a measure of the property of the material to retain energy arising from disturbance of its molecular structure.

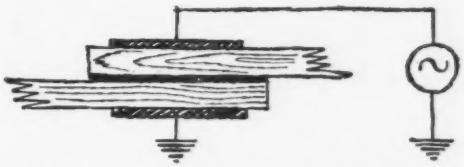
Cos Ø = the dielectric power factor of the load, that is the ratio of the power (in watts) to the product (in volt-amperes) of the voltage and current. This is a characteristic property of the material.

Therefore, "loss factor" is a property of the material and a measure of the ease with which it can be heated by this method. Like other physical properties, it varies considerably for different substances. The equation shows that the heat generated in a dielectric is proportional to its loss factor, but the rate of rise of temperature will also depend upon its specific heat and density. The following table gives approximate values of the dielectric constant, power factor and loss factor of a few typical dielectric materials for frequencies around a million cycles a second.

MATERIAL	DIELECTRIC CONSTANT	POWER FACTOR	LOSS FACTOR
Natural Rubber	2.9	0.02	0.058
Oak, dry	3.3	0.04	0.132
P.V.C.	5.3	0.06	0.318
Urea formaldehyde	7.0	0.03	0.21
'Bakelite' resin	6.0	0.03	0.18
Nylon	3.7	0.05	0.185
Water, pure	80.0	0.03	2.40
Water, tap	80.0	0.5/5.0	40/400

The high loss factor of water means that materials which are difficult to heat when completely dry will often heat efficiently when moisture is present. The voltage must be increased towards the end of the process in some cases to remove the final moisture traces, the reduction in loss factor as the material dries out providing a safeguard against overheating.

Dielectric heating of a homogeneous material is a straightforward application, heat being generated uniformly throughout. If the workpiece is made up of a number of materials, each material will heat up uniformly but each at a rate depending upon its loss factor, thermal properties and density. The degree of temperature uniformity throughout the workpiece will then depend upon the extent to which thermal conductivity can equalise different rates of heating.



Such different rates of heating can be turned to good account in certain applications. For example, in wood glue setting, the glue lines heat up much more rapidly than the wood pieces being joined and the glue sets before the wood heats up substantially, wood having a lower loss factor than glue. Dielectric heating does not depend upon any external heat source to transfer heat by conduction, convection or radiation to the surface of the charge and from thence to the interior by conduction.

Instead, heat is generated within every particle of a body placed in the dielectric field and, depending upon the uniformity of such a body, an even and extremely fast temperature rise can be achieved.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available—"Induction and Dielectric Heating" is an example.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

4776

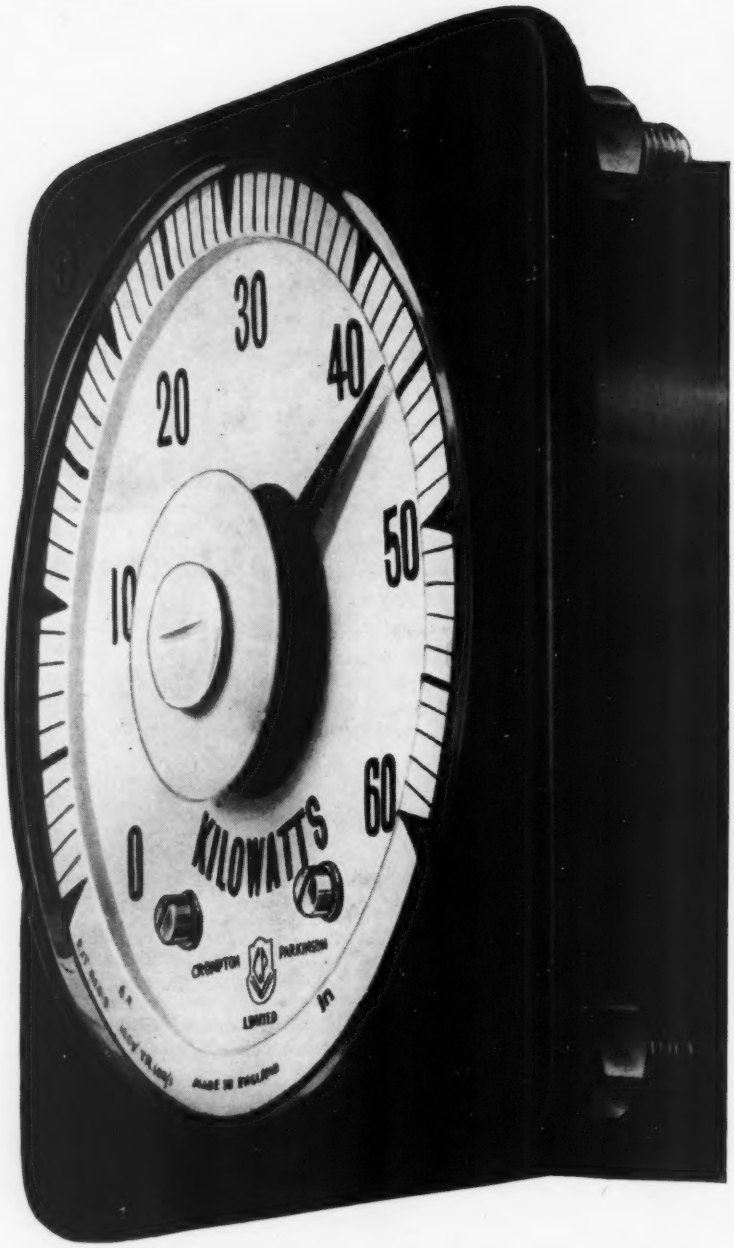
A NEW RANGE OF INSTRUMENTS

EASIER TO READ . . .

FROM ANY ANGLE . . .

CROMPTON PARKINSON

'NEW-WORLD'



This is what the dial looks like at 60° from the centre line – it can obviously be clearly read over a total angle of 120°: just one advantage of the front-line scale and contoured window of Crompton Parkinson 'New-World' instruments.

Shadow-free dial – scale is level with front of bezel and forward of panel.

Less reflection glare – glass contours minimise 'flashing' from adjacent light sources.

No light striations – glass rim has minimum lens effect – no break-up of transmitted light.

Long clear scale – 6½ in. scale on 3½ in. dia. platform dial. Bold cardinals and figuring ensure speedy no-error readings.

Unobtrusive fixing – Integral corner-fixing studs.

Full range – Ammeters and Voltmeters, moving-iron and moving-coil; Wattmeters: Frequency, Speed, and Power-Factor Indicators: Rotary Synchroscopes.

'New-World' instruments embody many Western-hemisphere design features. Your product will have increased acceptance in dollar markets if it carries 'New-World' instruments.

Crompton Parkinson LIMITED

ELECTRICAL EQUIPMENT

MAKERS OF ELECTRIC MOTORS OF ALL KINDS, A.C. AND D.C. GENERATORS, SWITCHGEAR, B.E.T. TRANSFORMERS, CABLES, INSTRUMENTS, LAMPS, LIGHTING EQUIPMENT, BATTERIES, STUD WELDING EQUIPMENT, TRACTION EQUIPMENT, CEILING FANS

CROMPTON HOUSE · ALDWYCH · LONDON · WC2

PRECIMAX
for Angular grinding

"PRECIMAX" MPH
ANGULAR HEAD MACHINE

GRINDING CAMSHAFTS AT THE ROVER CO. LTD.

For form grinding shoulders and flanges on these camshafts, the Rover Company use the PRECIMAX angular system, which is unsurpassed in its combination of accuracy and speed of production. The machine shown is the PRECIMAX MPH. 10/24/45/90 Cylindrical Grinding Machine, one of a complete series of angular head machines which embody such valuable features as the combined hydraulic tailstock and wheel truing device. Models are available with alternative wheelhead angles of 30 deg. and 45 deg., and with direct or oblique wheelhead approach. Full details of the entire range are available on request.

LANDIS LUND LTD
CROSS HILLS KEIGHLEY
ENGLAND
Tel: Cross Hills 3211

NRP/M4

wm LATHES *at* ROTAX LTD

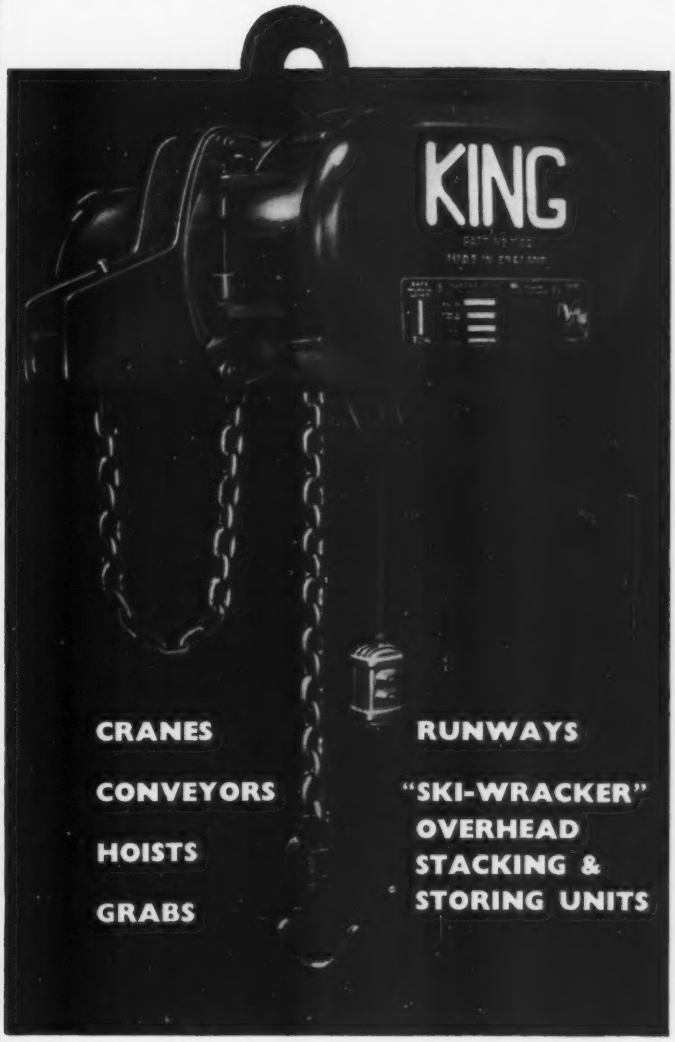
Rotax Ltd. have a number of WM 70 Junior 7" Centre Lathes in their Apprentice Training Workshop. Only the best is considered good enough for this important work, and there is no better lathe in its range than the WM 70.

Stand No. 54
at the Machine Tool Exhibition,
Olympia, in June

WOODHOUSE & MITCHELL

WAKEFIELD ROAD
BRIGHOUSE YORKS
PHONE :— BRIGHOUSE 627 (3 LINES)
GRAMS :— 'WOODHOUSE BRIGHOUSE'
WM.27.

the finest lifting tackle in the world is BUILT HERE!



CRANES
CONVEYORS
HOISTS
GRABS

RUNWAYS
"SKI-WRACKER" OVERHEAD STACKING & STORING UNITS

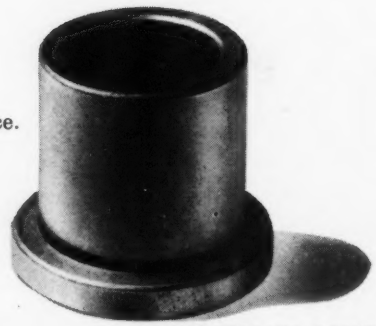
KING of Stevenage
Materials Handling Specialists

REGISTERED TRADE MARK

Write for further details and illustrated literature to:
GEO. W. KING LTD · ARGYLE WORKS (I.P.E.) · STEVENAGE · HERTS. *Telephone: Stevenage 440*

BOUND BROOK for POWDER METALLURGY

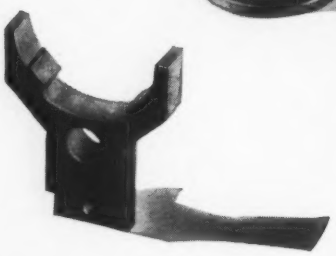
We are specialists in the manufacture of self-lubricating bearings and engineering components by the Powder Metallurgy process. Since 1922 our contact with every type of industry has brought us a knowledge and experience which enables us to offer a service to our customers which is second to none. If you have a specific problem regarding the use of sintered components our technical and design departments are at your service.



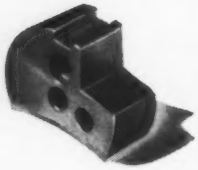
LUBROOK POROUS BRONZE BEARINGS. Of strong, uniform bronze structure, providing a continuous body of miscroscopic pores which hold from 25% to 35% lubricant by volume.

FERROCITE SINTERED IRON BEARINGS. An alternative to solid bronze, cast steel and other critical materials. Ensure rapid, low-cost installation and lasting, trouble-free operation.

LUBROOK AND FERROCITE SINTERED METAL PARTS. Complex shapes to close tolerances in materials to suit a wide range of applications. Impregnated for self-lubrication.



POLYSLIP P.T.F.E. IMPREGNATED BRONZE BEARINGS. For special applications where fluid lubrication is not permissible these bearings afford dry-film lubrication with a low coefficient of friction.



BOUND BROOK BRONZE FILTERS. These are produced from spherical metal powders of closely controlled particle size to give a rigid bronze structure of uniform pore dimensions. With excellent resistance to impact they are readily cleaned and can be used indefinitely. Available in six grades in many shapes and sizes.

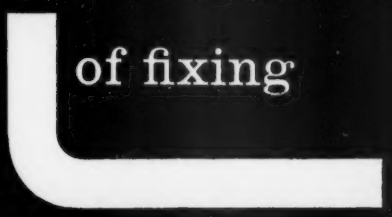
SINTERED BRASS PARTS High electrical conductivity combined with excellent machining properties make this material particularly useful in Electrical and Electronic applications.

BOUND BROOK BEARINGS LIMITED

TRENT VALLEY TRADING ESTATE, LICHFIELD, STAFFS

Telephone: Lichfield 2027-2028 Grams: Boundless, Lichfield

Member of the **Birfield Group**

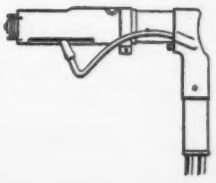
What is
the cheapest
and simplest way
of fixing
this . . . 
to this? . . .

When both are metal—the answer is almost invariably stud welding. The cost may be as little as one fifth of, for instance, the cost of drilling and tapping. The time an even smaller fraction. And stud welding is far stronger than any alternative method and absolutely permanent.

Stud welding is speeding up production and lowering costs in an immense range of industries from shipbuilding to domestic equipment. Attachments may be of almost any shape. A talk with our Engineers perhaps, followed by a demonstration, will be worth your while.

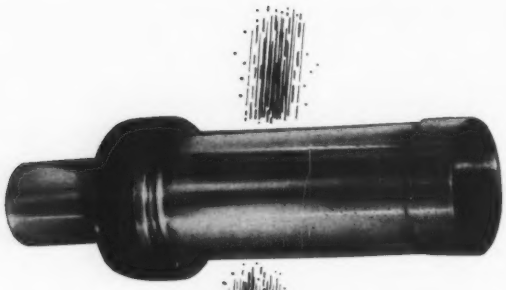
Crompton Parkinson

STUD WELDING

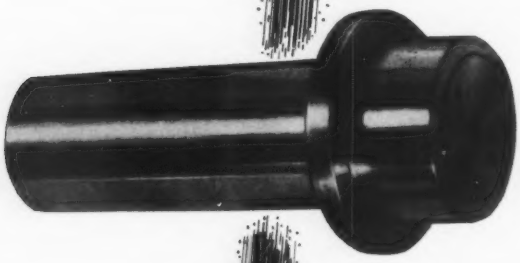


ELECTRICAL EQUIPMENT

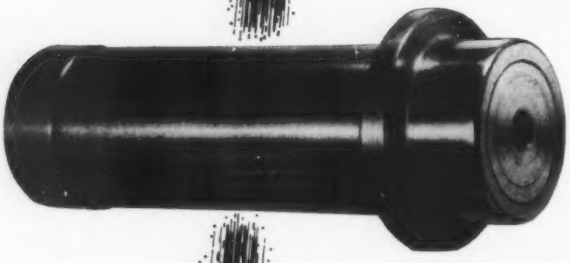
CROMPTON PARKINSON (STUD WELDING) LIMITED
1-3 Brixton Road, London, S.W.9. Telephone: Reliance 7676



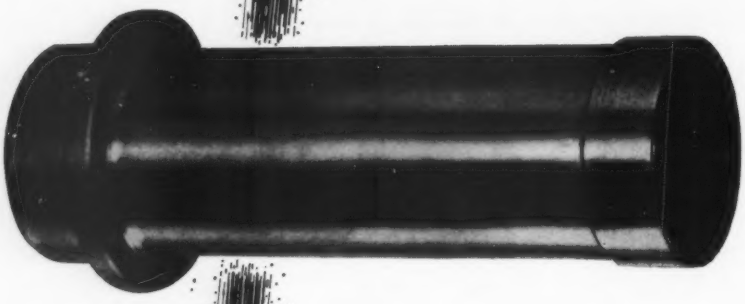
Perfection!



UNIBLAST



C.T.B NOZZLES



FOR LONGER LIFE!

MANUFACTURED BY

IMPREGNATED DIAMOND PRODUCTS LTD · TUFFLEY CRESCENT · GLOUCESTER

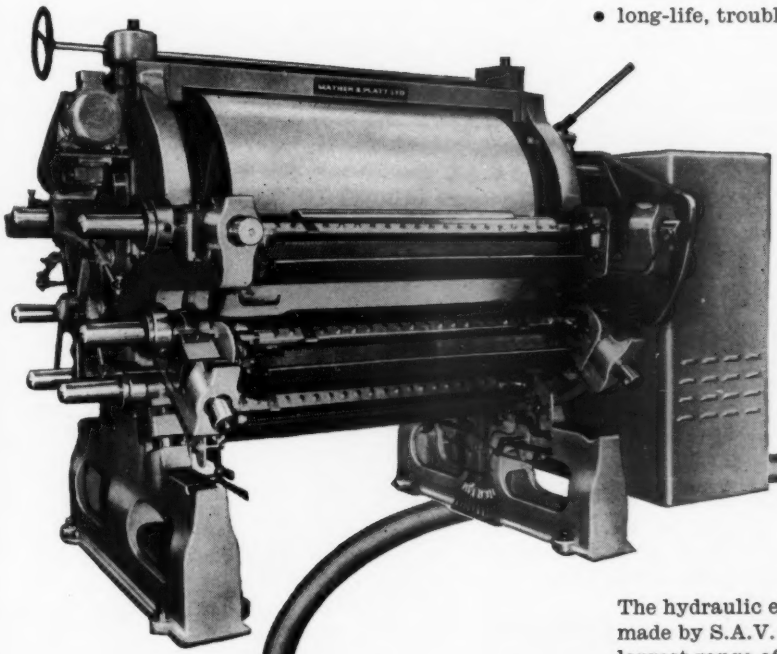
DISTRIBUTED BY

UNIVERSAL GRINDING WHEEL COMPANY LIMITED · STAFFORD · TELEPHONE: STAFFORD 381

Hydraulics for this Mather & Platt Textile Printing Machine:

to provide a pressure control system for the engraved printing rollers giving

- easy selection of pressure with accurate repetition from day to day
- constant pressure, with complete absorption of shock loads due to stitchings between ends of fabrics
- pressure evenly applied at both ends of roller
- high loads—up to 6 tons per roller
- speedy setting-up
- rapid response
- long-life, trouble-free operation



Made by:

The hydraulic equipment for this machine was made by S.A.V. Hydraulics—makers of Britain's largest range of dependable, job-proven hydraulic components. S.A.V. provide free technical advice and circuit design; complete installation; full after-sales service all round the world; and free tuition for Technical and Maintenance staff at S.A.V. Hydraulics Schools.

Why not have an exploratory discussion with one of our engineers?

SAV Hydraulics

STEIN ATKINSON VICKERS HYDRAULICS LIMITED

197 Knightsbridge, London, S.W.7. *Telephone: KNightsbridge 9641*

MECHANICAL HANDLING EXHIBITION
EARLS COURT 3-13 MAY
SEE OUR EXHIBIT

Technical Sales and Service at London, Birmingham, Glasgow, Leeds and Manchester.

MANUFACTURERS IN BRITAIN OF VICKERS HYDRAULICS

S.A.S. 4

STRATELINE
SPEED REDUCERS

The photograph above shows the type CW1 Strateline unit fitted to a Rolls-Royce Dart Aero Engine Overhaul Stand designed and manufactured by Messrs. Morfax Limited, of Mitcham, Surrey. The high efficiency and compact assembly of the Strateline makes it particularly suitable for manual operation and many variations have been supplied for high pressure valve operation, hand winch units, furnace tilting, etc. Where reasonable quantities are involved we are prepared to design special units against particular applications.

- This Strateline unit has an output capacity of 7,000 lbs. ins. required by maximum out of balance conditions whilst working on the Engine.
- The ratio illustrated is 60 : 1, but ratios between 20 : 1 and 100 : 1 are provided by the hypocycloidal gearing.
- Self-sustaining Strateline mechanism which operates when movement of handle ceases — the engine can be rotated. and sustained at any position, through 360°.

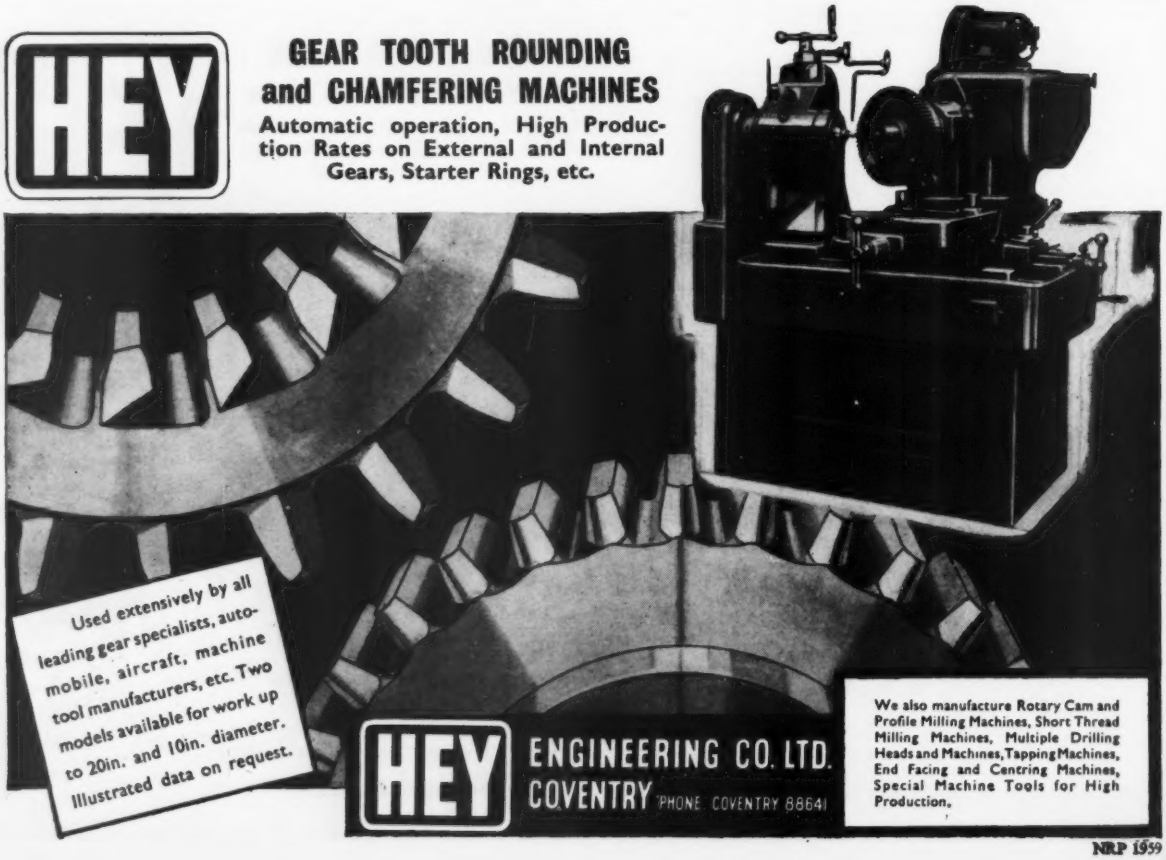
VARATIO - STRATELINE - GEARS LTD.

277-279 ABERDEEN AVENUE,
TRADING ESTATE, SLOUGH, BUCKS

HEY

GEAR TOOTH ROUNDING and CHAMFERING MACHINES

Automatic operation, High Production Rates on External and Internal Gears, Starter Rings, etc.



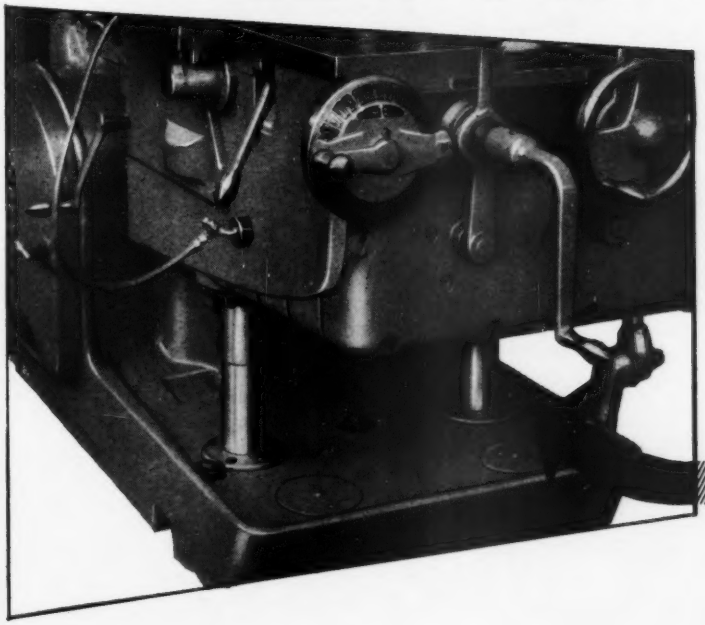
Used extensively by all leading gear specialists, automobile, aircraft, machine tool manufacturers, etc. Two models available for work up to 20in. and 10in. diameter. Illustrated data on request.

HEY ENGINEERING CO. LTD.
COVENTRY PHONE COVENTRY 88641

We also manufacture Rotary Cam and Profile Milling Machines, Short Thread Milling Machines, Multiple Drilling Heads and Machines, Tapping Machines, End Facing and Centring Machines, Special Machine Tools for High Production.

NRP 1959

Exclusive Twin Screw Support for Greater Rigidity...



KEARNEY & TRECKER MILWAUKEE*

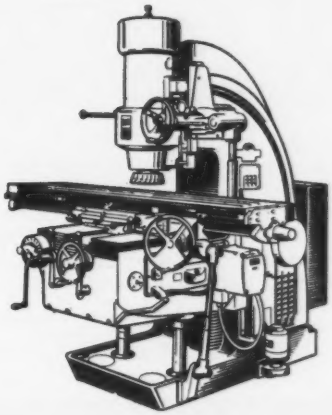
TF SERIES

* Regd. Trade Mark in Great Britain.

- TF Increased saddle support with heavy, wide one-piece knee.
- TF Longer cutter life—smooth action, with fly-wheel mounted three bearing spindle.
- TF Maximum knee support with solid back; massive column.
- TF Improved stability under heaviest cutting loads—greater resistance to torsional thrust with twin screw knee support.

INTERNATIONAL MACHINE TOOL EXHIBITION 1960
Olympia · London June 25-July 2
STAND No's. 32 & 321
GRAND HALL

Horizontal and vertical machines sizes 2, 3, and 4 up to 30 h.p. All models incorporate as standard monolever and automatic cycle table control.



E. H. JONES (MACHINE TOOLS) LIMITED

GARANTOOLS HOUSE · PORTLAND ROAD · HOVE · SUSSEX
Telephone: HOVE 47253 Telegrams: Garantools, Portslade

LONDON · BIRMINGHAM · GLASGOW · MANCHESTER · BRISTOL

HRP 2459

for RELIABLE S.G. IRON CASTINGS

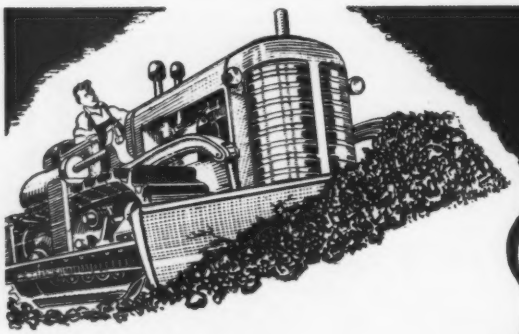
Pioneers in the development of this versatile new material, S.G. Iron, S. Russell & Sons Ltd. produce in addition to BS 2789 types 1, 2A and 2B, many other special types, including Austenitic. S.G. Iron gives a high yield strength combined with good machinability, the strength of steel and the rigidity of cast iron. It can be used as alternatives to many other and more expensive metals for a variety of applications, details of which will be gladly given.
S.R.S. also supply all varieties of High Duty and Alloy Irons and Grey Iron for machine tool and general machining purposes, in a wide range of sizes and quantities.

We shall be pleased to receive your enquiries.

S. RUSSELL & SONS LTD
FOUNDRY DIVISION
Head Office: Bath Lane, Leicester. Phone: 23211 (6 lines)

FIRST FOR S.G. IRON CASTINGS

SR592

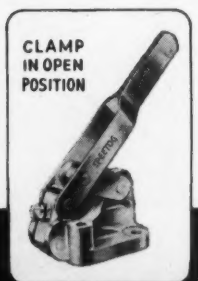


Speetog BULLDOZER CLAMP

Specially Designed to Give a Heavy Forward Thrust on a Fairly Short Stroke

This new and powerful clamp known as the "Bulldozer" is a recent addition to the world-famous range of Speetog instantaneous clamping equipment. It provides a compact toggle-operated tool for side or end clamping in the minimum of space, since the hand lever and toggle links move in a vertical plane. Clamp is only 2½in. high in the closed position, so that there is ample overhead clearance for milling and surface grinding operations, etc.

Patent No. 627324



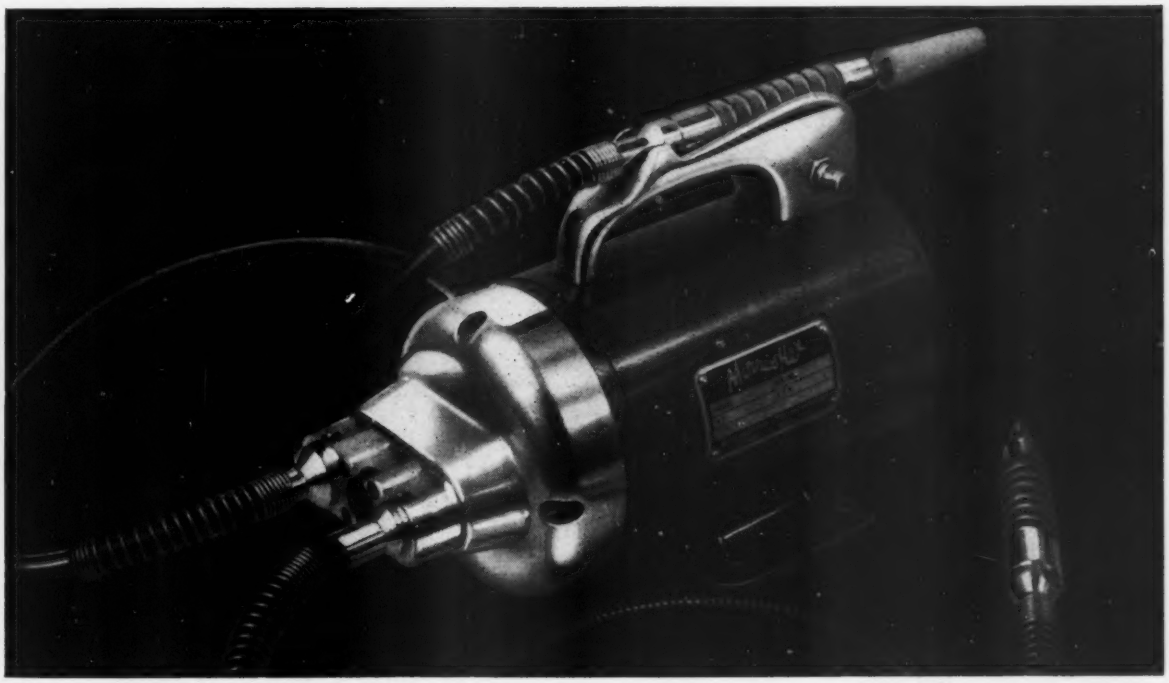
Speed Tools Ltd
VEREKER HOUSE, GRESSE ST., LONDON W.1. Museum 1039/1099.

NRP

INTRODUCING THE *NEW*

Morrisflex 300

FLEXIBLE SHAFT MACHINE



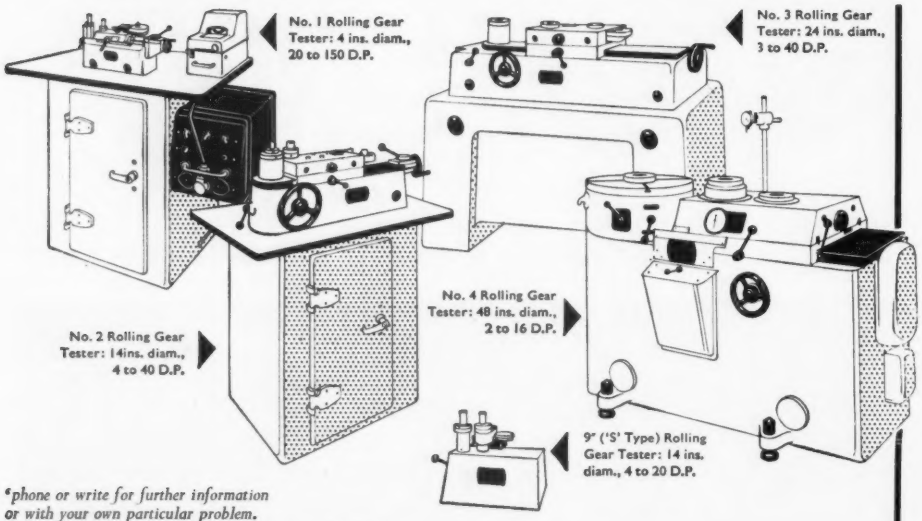
QUICKER SPEED CHANGE
LIGHTER TO HANDLE
EASIER TO MANOEUVRE
FINER FINISH OBTAINED

The M300 is an entirely new machine specially designed for use in the tool room and in all cases where finish is of paramount importance. Optimum speeds are available for cutters in steel or carbide.

Details from

B. O. MORRIS LTD., MORRISFLEX WORKS, BRITON ROAD, COVENTRY. TELEPHONE: 53333 (P.B.X.)

Goulder -an instrument for every gear test


No. 1 Rolling Gear Tester: 4 ins. diam., 20 to 150 D.P.
No. 3 Rolling Gear Tester: 24 ins. diam., 3 to 40 D.P.
No. 4 Rolling Gear Tester: 48 ins. diam., 2 to 16 D.P.
No. 2 Rolling Gear Tester: 14ins. diam., 4 to 40 D.P.
9" ('S' Type) Rolling Gear Tester: 14 ins. diam., 4 to 20 D.P.

The Rolling Gear Testers illustrated are only part of a wide range. Goulders can supply Gear Testing Instruments for *any* type of gear which can be instrument-mounted.

'phone or write for further information or with your own particular problem.

J. Goulder & Son Ltd. Kirkheaton, Huddersfield. Tel: Huddersfield 5252-3

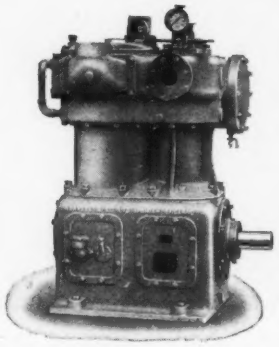
JG10

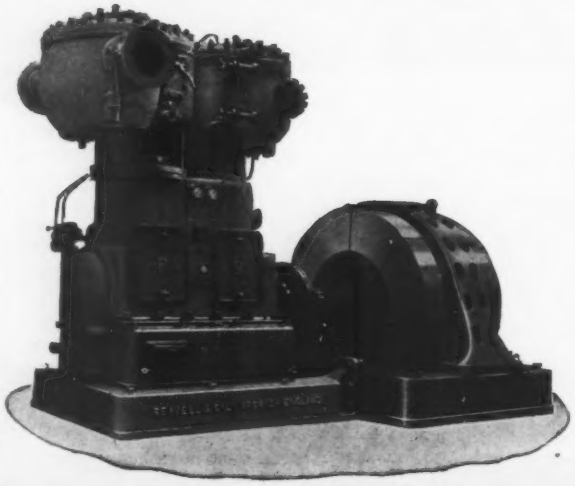
WHEN YOU ARE WANTING NEW

AIR COMPRESSORS

DO NOT FORGET THAT WE HAVE

A COMPLETE RANGE TO SUIT ALL DUTIES





Whatever it is you need—large or small capacity —high or low pressure—we can supply the best machine for the purpose, and our fifty years of specialised experience are at your service.

REAVELL & Co. Ltd.

IPSWICH

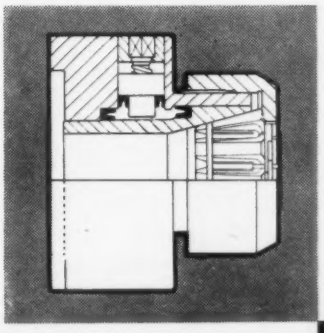
Telegrams: Reavell, Ipswich Telephone No.: 56124

ONE MULTIBORE

The Crawford Multibore Collet grips many sizes accurately and powerfully without slip, mark or distortion. Infinitely variable throughout its $\frac{1}{8}$" capacity, a single Multibore replaces many conventional collets. Multibore Collets can accommodate any diameter between $\frac{1}{8}$" and 2", or metric and decimal equivalents. Also Hexagon and Square within its capacity. It is partnered in efficiency by the remarkable Crawford Hydraulic Chuck.

Crawford Hydraulic Chuck

With its own, self-contained hydraulic system free from any wear and tear or gears, toggles, balls or cams, it is the most powerful dead-length chuck in the world. Send for descriptive leaflet today.



REPLACES MANY CONVENTIONAL COLLETS

London Stockists : Acbars Limited, 16-18 Macleod Street, Walworth Road, London SE17. RODney 7191

Midland and North-West England Stockists : Retselp Engineering Ltd., Vulcan Road, Industrial Site, Lode Lane, Solihull, Birmingham. Solihull 2239

Agents for North-East England : Alfred Herbert Ltd., Carliol Square, Newcastle 1. Newcastle 28864

Agents for Scotland : R. McSkimming & Co., 65 West Regent Street, Glasgow C2. DOUglas 7391-2

CRAWFORD COLLETS LIMITED

Witney : Oxon : Tel.: Witney 334

MASSIVE OR MIDDLEWEIGHT

. . . *everything flows freely on*

For factory or warehouse. Huge mobile testing equipment, massive trolleys, the lightest storage bin—all are gliding easily from place to place, moved with a minimum of effort. Industry is flowing smoothly, freely, efficiently—thanks to FLEXELLO, the largest manufacturer of castors in Europe. Made to the most rigid standards, to support weights from a few pounds to twenty tons, there's a FLEXELLO castor from our vast range to cater for all requirements.

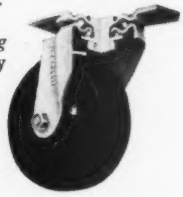
This castor was specially designed and produced for aluminium production and has a load capacity of from 10 to 12 tons.

For further particulars write for catalogue PR
FLEXELLO CASTORS & WHEELS LTD. SLOUGH, BUCKS. TEL: SLOUGH 24121

Flexello

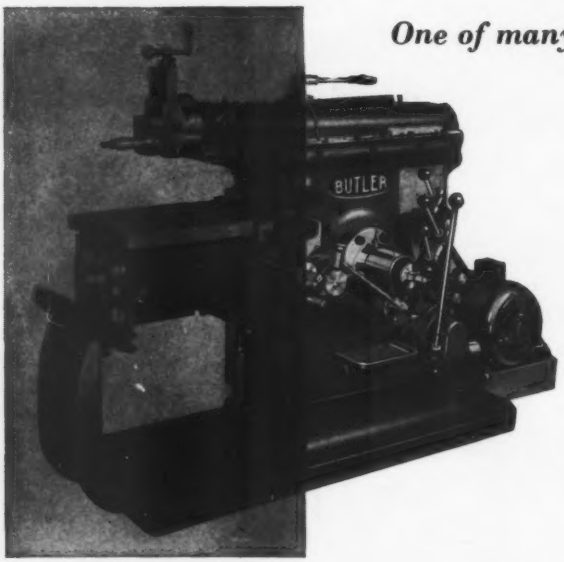
constant quality castors

'44' SERIES CASTORS: A special series of *Double Ball Bearing* heavy medium duty castors, specially manufactured for export which have now become available for the home market.



MECHANICAL HANDLING EXHIBITION
EARLS COURT MAY 3-13
STAND GG16 (Balcony)

DTV



One of many different types of machines

SAVED! *by*

BROCKHOUSE

MACHINE TOOL REBUILDING SERVICE

BROCKHOUSE
J. BROCKHOUSE & CO. LTD.
Machine Tool Division
ELMS WORKS · WOLVERHAMPTON
Tel.: 23801

Why not consult us about that one-time useful machine tool which is now standing idle? We have a comprehensive machine tool rebuilding service available for LATHES, AUTOMATICS, MILLERS, SHAPERS, PRESSES and DIE CASTING MACHINES Machines are completely stripped, parts replaced and when rebuilt carry our six months' guarantee.

SEND FOR DESCRIPTIVE LEAFLET.

ORMEROD

SLOTTING MACHINES

with adequate power and rigidity for Heavy Duty

★ **A High Production Machine Powerful and Precise**

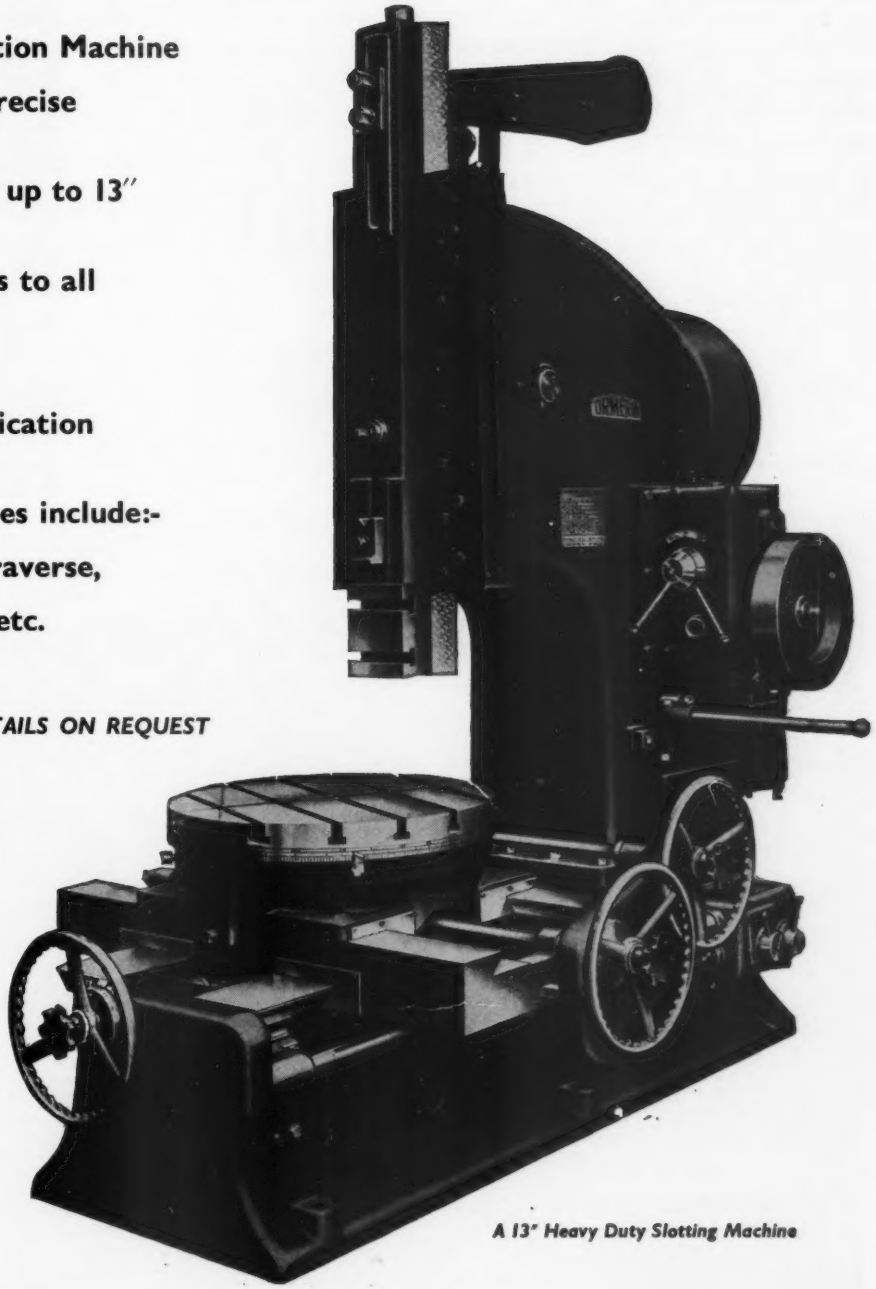
★ **Variable stroke up to 13″**

★ **Automatic feeds to all table motions**

★ **Automatic lubrication**

★ **Optional features include:- Rapid Power Traverse, Canting Table, etc.**

LIST SL9 WITH FULL DETAILS ON REQUEST



A 13″ Heavy Duty Slotting Machine

A range of Slotting Machines is available from 4″ to 26″ stroke

ORMEROD SHAPERS LTD. *Member of the Asquith Machine Tool Corporation*

HEBDEN BRIDGE, YORKS, ENGLAND *Telegrams : 'Shapers', Hebden Bridge. Telephone : Hebden Bridge 17 and 313*

OS380

Does chip welding trouble you?

Many machining difficulties—poor finish, lack of accuracy, reduced tool life—derive from the welding of chips to the tool when cutting. But these are essentially symptoms. The real trouble is inadequate performance of the coolant. The cure may be a change to FLETCHER MILLER cutting fluids. They cool the chip, the tool and the workpiece thoroughly; they lubricate the tool and chip, creating an anti-weld effect between them. As a consequence, higher speeds or feeds are possible whilst maintaining accuracy and finish. The whole range of FLETCHER MILLER cutting fluids is described in our Publication SP. 173 "Cutting Fluids". We will be pleased to send you a copy if you write on your business letter heading.

SWIFTEX
This straight oil is supplied in two grades. Sulphurised to undertake heavy work under severe tooling conditions and non-sulphurised for high performance work on non-ferrous metals and special alloys. Either blend is very suitable for gear cutting.

specify FLETCHER MILLER *cutting fluids*

FLETCHER MILLER LTD., ALMA MILLS, HYDE, CHESHIRE.

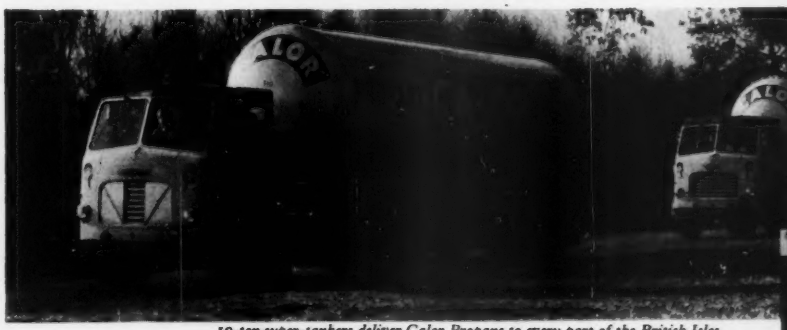
Telephone: HYDE 3471 (5 LINES) *Telegrams:* EMULSION, HYDE

CFI21

A NEW POWER IN THE LAND...

Calor Propane speeds production

A NEW POWER is abroad in Britain. Today a gas called Calor Propane is challenging established industrial fuels, opening new vistas of productivity. Giant 10-ton Calor tankers—the biggest propane fleet on Britain's roads—are already a familiar sight, speeding power to industry throughout the country. Already a list of all that Calor Propane is doing would fill this page twice over; already major industries are adjusting their development programmes to make full use of this important new industrial fuel.



10-ton super-tankers deliver Calor Propane to every part of the British Isles.

GOES ANYWHERE . . . DOES ANYTHING

You can use Calor Propane anywhere in Britain. For large-scale users a bulk supply system of road tankers delivering to on-site storage tanks is used. Smaller users are supplied with Calor Propane in cylinders through a nation-wide dealer organisation over 1,500 strong. Calor Propane makes it possible to build a biscuit factory on a work-starved hillside, or a comfortable canteen high in a half-finished skyscraper.

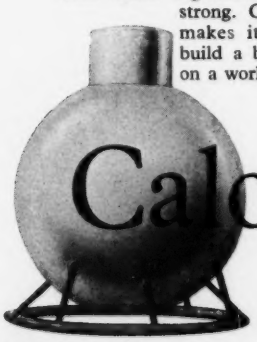
Calor Propane does away with the idea that a factory needs gas in the canteen, coal in the boiler, electricity for stoving ovens and petrol for fork lift trucks. Instead of half a dozen fuels you need only one—Calor Propane is so versatile you can put it in an engine instead of petrol, cook dinner or cut steel with it.

A special gouging torch in operation using Oxy-Calor Propane. Wherever clean, quick, economical heat is needed Calor Propane can do the job. Illustration by courtesy of British Industrial Gases Ltd.

Calor Propane is already hard at work in many industries :—

STOVE ENAMELLING · PROFILE CUTTING · PRE-HEATING FOR WELDING · FORK-LIFT TRUCKS · STATIONARY i/c ENGINES · SPACE HEATING · BRAZING & SOLDERING GLASS BLOWING · WATER HEATING · CANTEEN COOKING BLOW TORCHES · FLOODLIGHTING · DRYING OUT ANTI-CORROSION TANK HEATING · CUTTING TORCHES OVENS & FURNACES

These are just a few examples. Calor Propane can probably help you—our Research & Development Division will be pleased to offer their advice.



Calor Propane

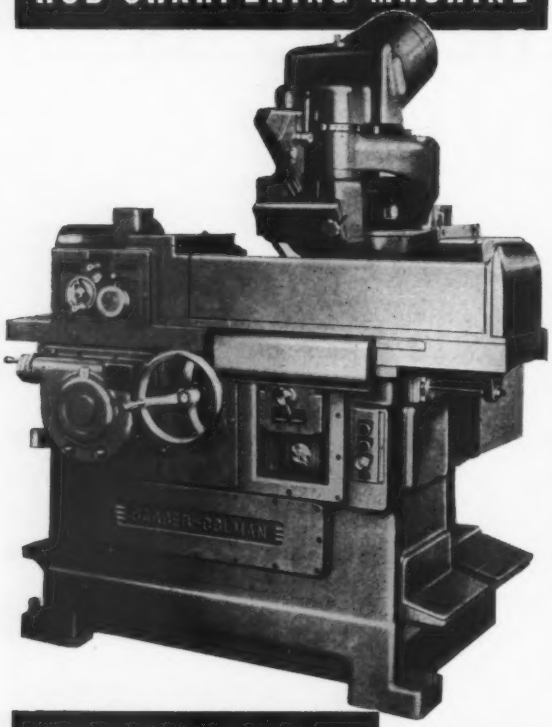
THE MODERN INDUSTRIAL GAS

SUPPLIED BY **CALOR GAS**

distributors of domestic Butane and industrial Propane gas.

ENGLAND & WALES: CALOR GAS (DISTRIBUTING) CO. LTD., 178-202 GT. PORTLAND ST., LONDON, W.1
SCOTLAND, N. IRELAND & EIRE: CALOR GAS (SCOTLAND) LTD., 11-13 WESTWOOD RD., POLLOKSHAWS, GLASGOW, S.3

THE NEW
BARBER & COLMAN
6-5 Hydraulic
HOB SHARPENING MACHINE



FEATURES

BARBER COLMAN
TRADE MARK

★ PRECISION SET-UP ADJUSTMENTS
★ WET OR DRY GRINDING
★ ACCURATE INDEXING
★ PRECISION BUILT-IN WHEEL DRESSER
★ ADJUSTABLE HYDRAULIC TABLE SPEED AND STROKE
★ AUTOMATIC FEED AND INDEX COUNTING
★ UNIT CONSTRUCTION

The new Barber-Colman No. 6-5 Hydraulic Sharpening Machine is a precision machine which controls index spacing, rake angle, lead of gash, and surface finish of the cutting tool to a degree which has never before been reached by any commercial sharpening equipment. Illustrated literature available on request.

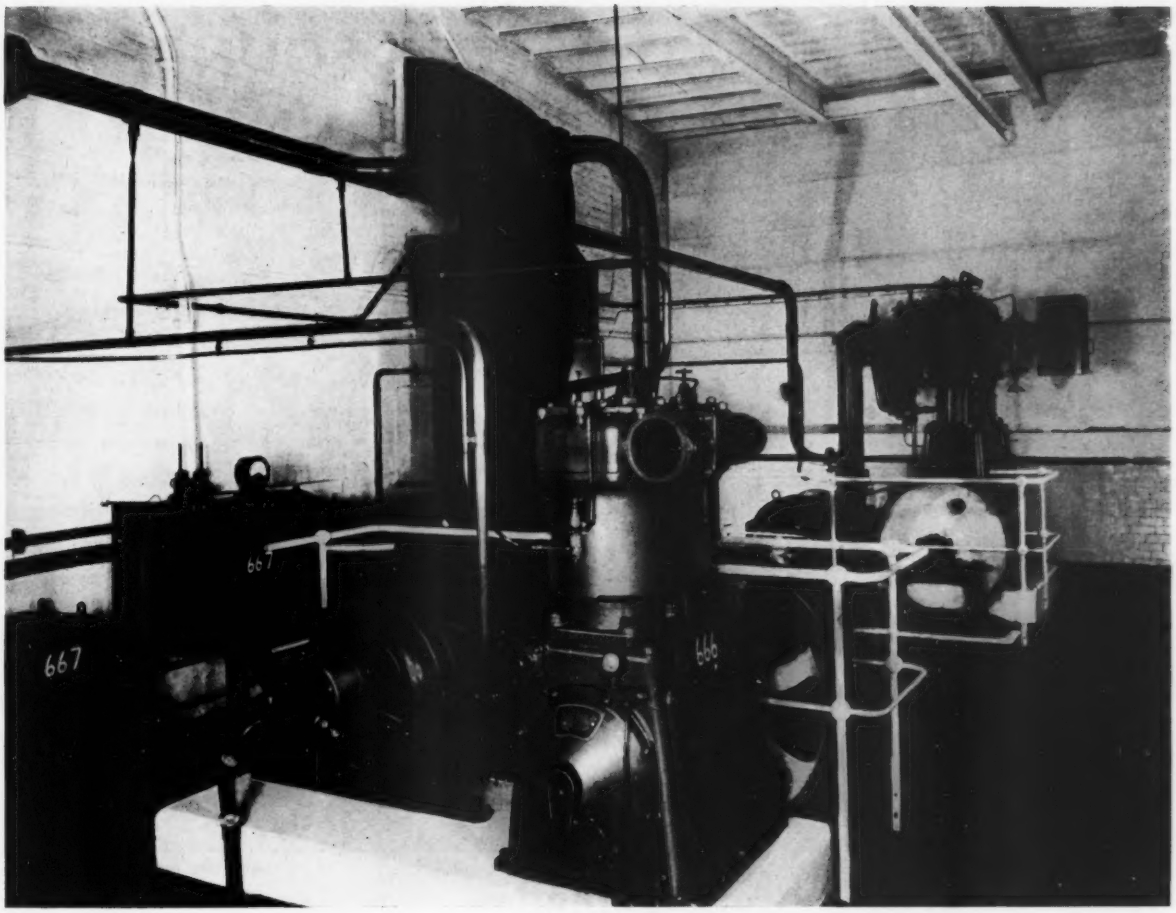
BARBER & COLMAN LIMITED
BROOKLANDS SALE CHESHIRE

Mechanical Steel Tubing

We carry
Mild Steel
Carbon Steel
Stainless Steel
TUBE

- In scores of diameters and wall thicknesses.
- In random lengths, or cut to any size (however short!).
- Thick wall tube a speciality.
- *Send for booklet which gives full particulars.*

Markland Scowcroft LIMITED
BROMLEY CROSS, NEAR BOLTON
Telephone: EAGLEY 600
MI36



Photograph by courtesy of T. F. and J. H. Braime Ltd. View of compressor house, showing part of the "BROOMWADE" installation.

"BROOMWADE" for Reliability

T. F. & J. H. Braime Limited rely on "Broomwade" air compressors with good reason.

Their first compressor was installed in 1922; the second in 1942; and the third in 1958. They have all worked uninterruptedly and efficiently.

The air is used for operating die cushions in power presses, air clutch/brake units driving medium to heavy presses, and hand riveting machines and grinders.

For continuous operation reliability is essential — you can certainly rely on "BROOMWADE".

"BROOMWADE"

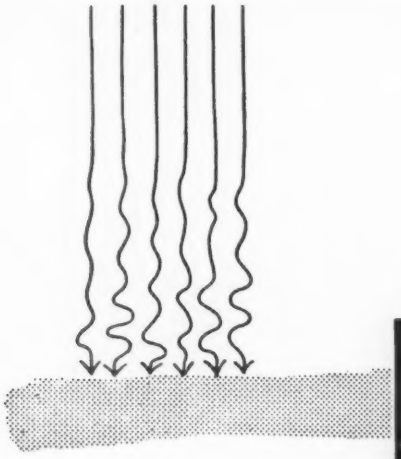
AIR COMPRESSORS AND PNEUMATIC TOOLS

YOUR BEST INVESTMENT

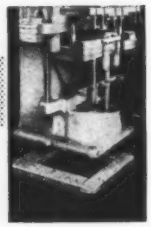
BROOM & WADE LTD., P.O. BOX NO. 7, HIGH WYCOMBE, ENGLAND

Telephone: High Wycombe 1630 (10 lines) *Telex 15-527*

726SAS



THERE'S A SOUND BARRIER IN INDUSTRY TOO!



More than 1,000 factories now use the Croid-Cooper method to combat noise and vibration, the arch-enemies of efficiency. In these factories each machine is simply stuck down on a felt base with a holding power of 50 lb. to the square inch, a felt base that absorbs more than 80% of vertical vibration in some cases, reducing the wear on machines and enabling them to produce more accurate work. Reducing the wear on operators' nerves, too. With the Croid-Cooper methods bolting and grouting are things of the past, and layouts can be changed overnight. Send for further details today.

CROID 65
MACHINE FIXING GLUE
COOPERS
FELT

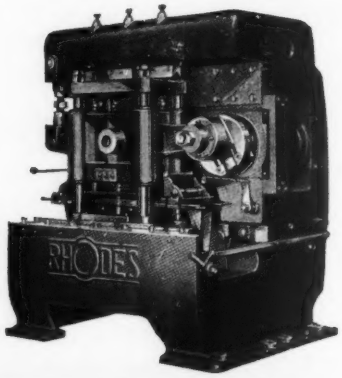
COOPER & CO. (B'HAM) LTD

Head Office and Works:
BRYNMAWR · BRECONSHIRE · Telephone 312

Branch Office and Works:
SEELEY'S ROAD · B'HAM 11 · Telephone VIC 5417

We offer you time gained— —Not gimmicks...

The beauty of this machine is that exceptional speeds are combined with quick changeovers.
It is certainly the fastest press in the world. 1,000 strokes per minute if you wish, but it is an economical proposition for relatively short runs.
Here it has a great advantage over single-purpose machines.
What is more, accuracy is truly remarkable—without the aid of pilot pins.
There are no feed rolls and tool 'life' is prolonged.
It is an original design patented by Rhodes.
This press crosses the Atlantic Ocean from *east* to *west*.
All the gimmicks in the world can't add up to the know-how we've accumulated and progressively applied since metalworking first started. We've been at it for 136 years.



RHODES
ULTRA-SPEED PRESSES

1,000 strokes per min. Makes the roll-feed dieing press obsolete.

BUILT TO THE **RHODES** STANDARD

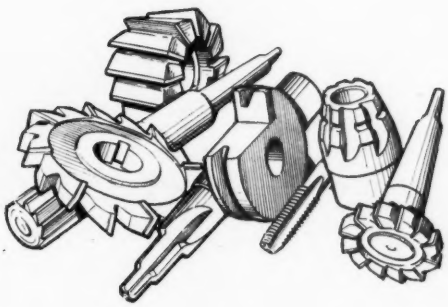
RHODES OF WAKEFIELD

JOSEPH RHODES AND SONS LIMITED
BELLE VUE · WAKEFIELD · TELEPHONE 2756 (3 lines)

HRP 2933

grinding costs...

AND TOOL COSTS



Prolonged tool and cutter life, and better quality finishing are yours with the Union Tool and Cutter Grinder.

UNION
TOOL AND CUTTER GRINDER

PAYS OFF IN TOOL SAVINGS

COMPLETE WITH CABINET BASE OR FOR BENCH MOUNTING

Send for fully detailed leaflet TODAY

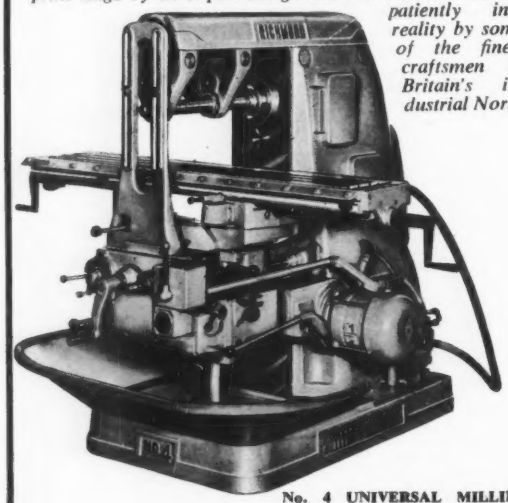
T. S. HARRISON & SONS LIMITED · HECKMONDWIKE · YORKSHIRE

We are exhibiting at the **INTERNATIONAL MACHINE TOOL EXHIBITION** *on* **STAND 404, NATIONAL HALL GALLERY, OLYMPIA** *June 25-July 8*

RICHMOND

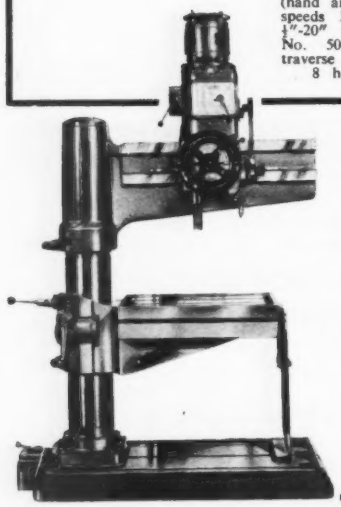
Range the world over!

Speed, rigidity, flexibility. These are the basic points that the discerning buyer looks for in a machine tool. But these essential qualities don't just 'happen' — in the case of the famous "Richmond" range of Milling and Drilling Machines, they are factors built-in at the blue-print stage by an expert design team and then translated patiently into reality by some of the finest craftsmen in Britain's industrial North



No. 4 UNIVERSAL MILLING MACHINE

Table working surface 60″ × 12″. Longitudinal traverse (hand and auto) 40″. Cross traverse (hand and auto) 9″. Vertical traverse (hand and auto) 16″. 16 spindle speeds 30-700 R.P.M. 12 feeds ¼″-20″ per min. Spindle bored No. 50 B.S.S. Taper. Quick traverse to all table movements. 8 h.p. drive to spindle.



S.R. 2 RADIAL DRILLING MACHINE

9 spindle speeds 100-1500 R.P.M. or with reduction unit 50-750 R.P.M. 3 feeds .005″, .010″ and .015″ per rev. Spindle dia. 1¼″. Bored No. 3 M.T. Pillar dia. 9″. 36″ and 48″ — Radius of Drill spindle.

RICHMOND *MILLING AND DRILLING MACHINES*

MIDGLEY & SUTCLIFFE LTD.

Hillidge Works, Hunslet, Leeds 10, England

Telephone: 76032/3 Telegrams: 'Tools, Leeds, England'

THE 600 GROUP OF COMPANIES

Radio-Frequency—too!!

Over the years more and more companies have entrusted us with their components for FLAME HARDENING and learned its amazing possibilities.

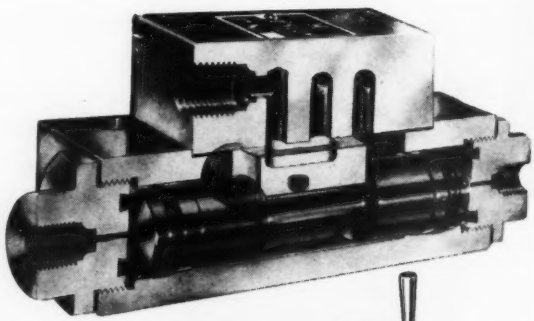
Meantime we have developed a RADIO-FREQUENCY Department and can offer service from Valve Generators up to 125 Kva.

On Starter Rings we have full automation. Yet we know there is still much to learn . . . remarkable possibilities!

FLAME HARDENERS LIMITED

Shorter Works · Bailey Lane · Sheffield I

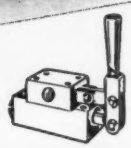
Telephone 21627



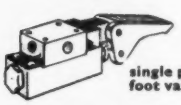
MILLIONS MORE

valve reversals

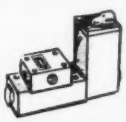
exclusive new development **INCREASES VALVE LIFE** many times



hand control valve



single pedal foot valve



single pilot SOLENOID operated control valve

Valve slides moulded from FLUON* are exclusive to the range of Midland Pneumatic 'FLUOSLIDE' Control Valves. *Having a coefficient of friction equalled only by wet ice on wet ice* such slides give millions more valve reversals.

All other working parts made from bronze or stainless steel. Range ¼″-1″ B.S.P. Short delivery. Also a complete range of cylinders from 1″ to 10″ bore, cushioned and non-cushioned. Send for catalogue.

*Regd. Trade Mark-I.C.I. LTD.

MIDLAND PNEUMATIC LTD

NEW CROSS · WOLVERHAMPTON

Telephone: 32501-2

a full range of rugged industrial compressors

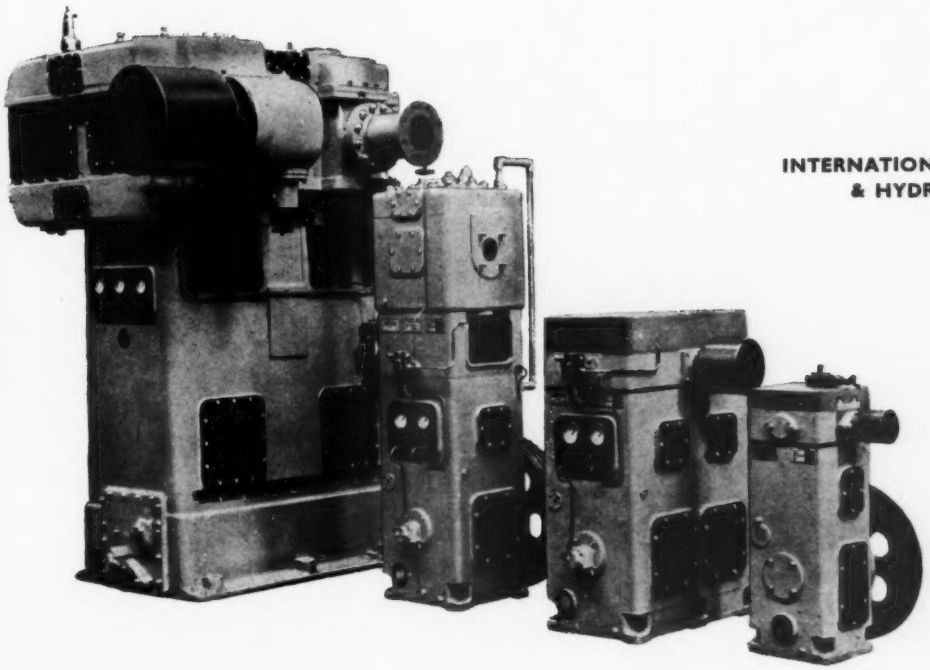
The large Compressor illustrated is typical of our 'Comoblok' range of machines. This range covers capacities from 500—2,000 c.f.m. These machines are of the double-acting crosshead type, and are suitable for pressures up to 50 p.s.i.g. single stage, and 150 p.s.i.g. two stage. They are remarkable for their low power consumption and compact design. Send for Leaflet No. T29.

The machine alongside is one of our Oil-free Range. These are available in capacities from 100 to 2,000 c.f.m., and at all pressures up to 150 p.s.i.g. They are specifically designed to deliver uncontaminated air, and have many special features incorporated which make them unique in this field of Compressors. Send for Leaflet No. T31.

The two smaller machines shown illustrate our 'Uniblok' and 'Twinblok' Range, and cover capacities of from 50 to 400 c.f.m. at all pressures up to 120 p.s.i.g. These are of the single stage, single acting type. Are styled to give a neat appearance and are unrivalled for their low maintenance and space saving features. Send for Leaflet No. T19.

Tilghman's have a complete range of Vacuum Pumps to offer in displacements from 500—2,500 c.f.m., and are capable of drawing 28" Hg. on a 30" Hg. barometer.

Tilghman's undertake the design and manufacture of special purpose Air & Gas Compressors, Boosters, etc., and welcome an opportunity of quoting for complete installations.

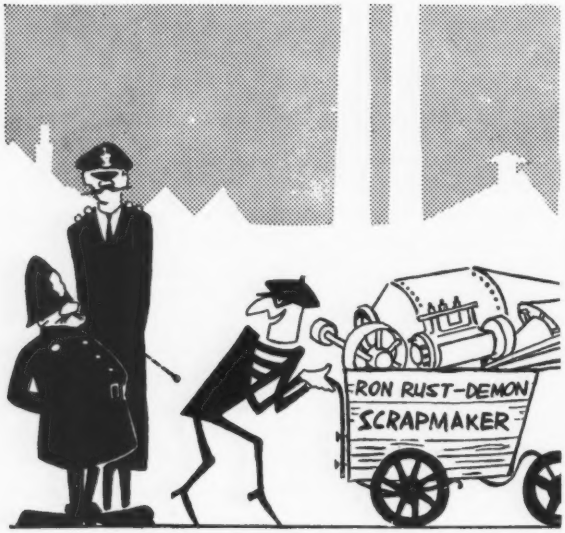


We are exhibiting at the
INTERNATIONAL COMPRESSED AIR & HYDRAULICS EXHIBITION
Visit us on stand
No. 31

Send for our informative and invaluable leaflet on "Selection, Installation and Maintenance of Air Compressors"

TILGHMAN'S *Limited* **AIR POWER DIVISION**
BROADHEATH · ALTRINCHAM · CHESHIRE

TELEPHONE: ALTRINCHAM 4242 (6 LINES) TELEGRAMS: TILGHMANS ALTRINCHAM
A Member of The Staveley Coal and Iron Co. Ltd. Group



Robbery unnoticed

YES, and it happens every day, probably in **your** production department.

Trouble is: you don't miss anything or you don't notice it, until **after** the damage is done. Your only course then may be to scrap your production in favour of a new lot which **must** be protected from rust quickly if the "rust thief" is not to rob you of another batch of brand new metal components.

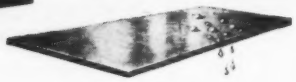
Rust can, and does, play the "very devil" with most types of ferrous components during storage, for either long or short periods. Prevent this trouble by applying RUST-VETO to your metal components immediately they leave your production department. The effectiveness of RUST-VETO has been proved by users over many years.

Different grades are available from grease to very fluid consistency. Also hard-drying types as well as special water-dispersing grades and finger-print neutralisers.

Recommendation and sample gladly submitted

RUST-VETO

Special water-displacing grades actually raise water off metal to form a long-lasting protective film under the moisture.



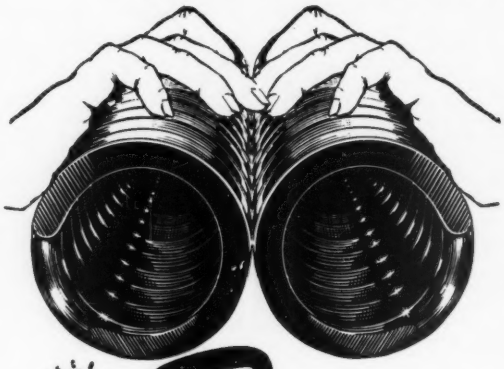
Research Service

Edgar Vaughan & Co. Ltd.

LEGGE ST., BIRMINGHAM, 4.

Works and depots at: Birmingham, Manchester, Liverpool, London (Southall), Bristol, Glasgow.

Looking in the right direction



Ratcliffe SPRINGS

F. S. RATCLIFFE (ROCHDALE) LTD.,
Crawford Spring Works, Norman Road, Rochdale
Phone: Rochdale 40415 'Grams: Recoil,' Rochdale Telex 63178

OUR NEW FACTORY— with Modern Plant can help with your PRODUCTION!

Specialists for many years in complete manufacturing of Pneumatic equipment. Improved methods of production enable us to make surplus plant available for undertaking other products in the wide field of General Engineering.

SPEEDY DELIVERY— COMPETITIVE PRICES

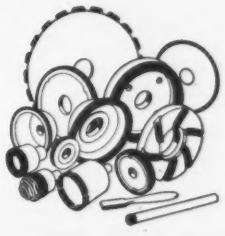
THESE MACHINES ARE READY TO SERVE YOU!
• Herberts No. 1, 2, 4 & 7 Capstans.
• Drilling Machines from .010" to 1¼" capacity.
• Honing Machines from ¼" dia to 12" dia.
M.H.HURST ENGINEERING LIMITED

- **Horizontal and Vertical Milling.**
- **Turning Capacity 3½" dia and 24" swing.**
- **Bar Automatics 1¾" dia max.** • **Chucking Automatics 12" dia max.**

ALL ENQUIRIES WELCOMED

COMMON LANE · KENILWORTH · WARWICKSHIRE
Telephone Kenilworth 891 *Telex 31551*

for perfection in diamond wheels



MANUFACTURED BY **IMPREGNATED DIAMOND PRODUCTS LTD · GLOUCESTER**

DISTRIBUTED BY **UNIVERSAL GRINDING WHEEL COMPANY LIMITED · STAFFORD**

ENV

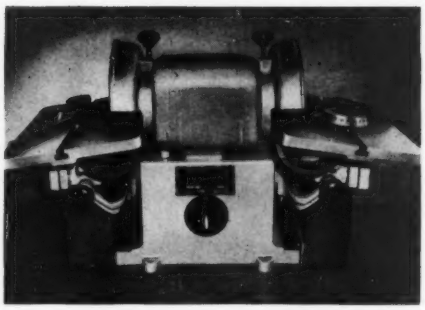
facilities for HEAT TREATMENT

The ENV heat treatment plant is one of the most modern and comprehensively equipped in the London area.
Facilities include full metallurgical control, quenching press equipment and electrically controlled flame hardening machine.
Enquiries for heat treatment of production quantities are invited.

E.N.V. ENGINEERING CO. LTD
HYTHE ROAD, WILLESDEN, N.W.10
TELEPHONE: LADbroke 3622

AP 112

GRIND & LAP on the "MASTERLAP"



● It has Features of the Future. NOW with Fibre-Glass all-enveloping guards and PVC Coolant Tanks. They can't corrode.

LESTER - BROWN MACHINE TOOLS LTD.
BAYTON ROAD WORKS, EXHALL, COVENTRY.
Telephone - Bedworth 2304

VACU-BLAST.

Will secure clean conditions in Reactor Vessels, Heat Exchangers, Pipes and Ducting.

This mobile, dust-free shot blast machine is being used with outstanding success for in-situ cleaning of nuclear power plant installations. Heat exchangers, Reactor-vessels, Boiler elements and ducting, all require the super cleaning for which Vacu-blast is perfectly suited. Vacu-Blast equipment is equally well suited to on-site construction work or pre-fabrication in the workshop. Demonstrations can be arranged on request.

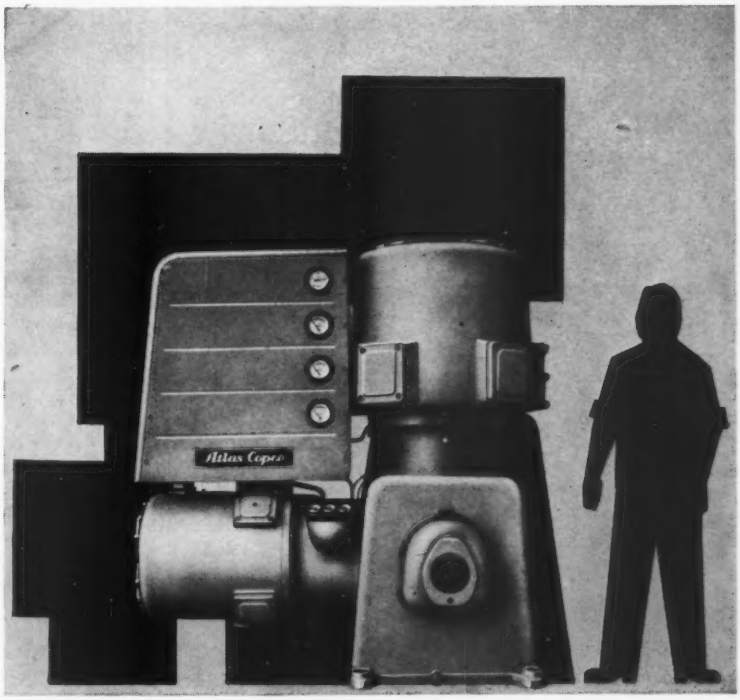
3 PAE/B

VACU-BLAST LIMITED, WELLCROFT ROAD, SLOUGH, BUCKS., ENGLAND Telephone : **Slough 24507 - 8 - 9**
VACU-BLAST (AUSTRALIA) PTY. LTD., AIRPORT WEST, VICTORIA, AUSTRALIA

New Compressor Design

GIVES OUTSTANDING SPACE SAVING WITH REDUCED RUNNING COSTS

The Atlas Copco ER6 is a new stationary compressor which uses fundamental improvements in design to achieve remarkable results in performance and efficiency. The illustration shows the size of the ER6 compared with a conventional compressor of similar output: yet this extraordinary saving in space is achieved with *added* efficiency and economy, and with the same reliability of operation, which has characterised Atlas Copco compressors for 50 years.



PRINCIPAL DATA

Maximum pressure in psi	Speed in rpm	Low-pressure piston displacement in cfm	Free air delivered at 100 psi in cfm	Cooling water required at 60°F approx in galls/hour	Weight in pounds
125	485	1,303	1,075	440	6,600

Economy of operation

The specific power consumption for the ER6 is 10-15% lower than for most machines of this size on the market. At 4,000 hours running time per year this means an *annual power saving of up to* £360.

In addition the cooling water consumption of the ER6 is very low because of the special design of the intercooler, amounting to only 440 gallons per hour at 60°F. This is less than half the quantity needed for the majority of other similar air compressors.

Economy of installation

The ER6 requires an exceptionally small amount of floor space for its capacity. This reduces the cost of foundation and erection, especially with the use of a flange-mounted motor.

Erection and alignment can be simplified by using a base frame which can be delivered as extra equipment. The balance is so good that the ER6 can be mounted on a skid frame, which does not require a concrete foundation. Skid frame mounting is especially advantageous for contractors and makes it possible for the compressors to be moved easily and at low cost from one site to another.

The ER6 is equipped with an oil pressure control device and cooling water gauges together with a full set of instruments for visual control.

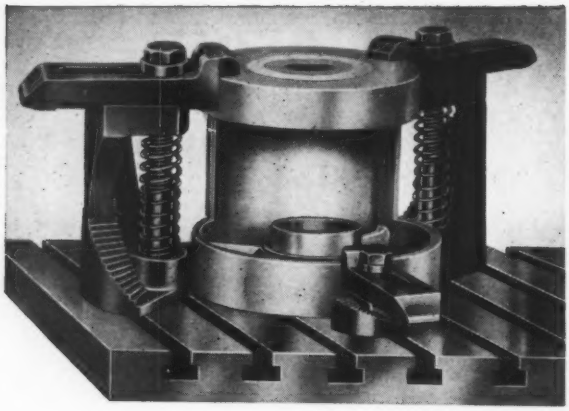
A complete range of compressed air equipment

Atlas Copco manufactures portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. Sold and serviced by companies or agents in ninety countries throughout the world.

Atlas Copco
COMPRESSED AIR ENGINEERS

ATLAS COPCO (GREAT BRITAIN) LIMITED
Maylands Avenue, Hemel Hempstead, Herts · Phone: Boxmoor 6040
Sales and Service Depots at: LONDON · BRISTOL · CARDIFF · MANCHESTER
WALSALL · LEEDS · GLASGOW · BELFAST · DUBLIN

5/58/07



For a quick SAFE Grip!

A range of popular sizes to suit
any T slot or clamping height.
No loose parts to lose.
Each size adjustable for height.
Any quantity Ex stock.

ROCKWELL HELICAL CLAMPS

BRITISH PATENT

Write or phone Dept. C/C for leaflet giving prices, sizes and full technical details

ROCKWELL MACHINE TOOL CO. LTD.

WELSH HARP, EDGWARE ROAD, LONDON, N.W.2. Tel: GLA 0033

Also at: Birmingham-Telephone Springfield 1134/5
Stockport-Telephone Stockport 5241 · Glasgow-Telephone Merrylee 2822
SC7

Let us be your machine shop!

Complete facilities plus precision & service second to none

- Capstan and centre lathe work
- Milling—all types
- Surface and universal grinding
- G-SIP jig boring
- Centreless grinding
- Copy turning

. . . as well as shaping, honing, drilling, tool-making, etc. to meet your every need. A·I·D & A·R·B Approved

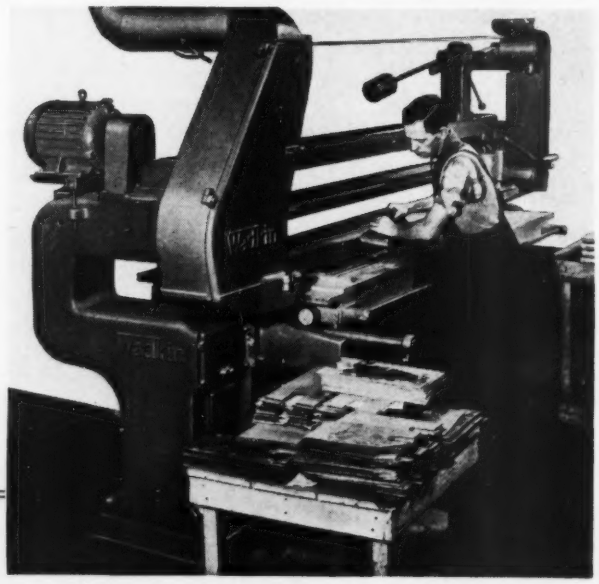
MARSDEN & SHIERS LTD.

Davis Road, Chessington, Surrey. Phone: Elmbridge 5333 (3 lines)

Wadkin

Metal Linishing Machines *produce a better finish-faster!*

● *The range of Wadkin Linishing Machines is fully described in publication No. 914. May we send you a copy?*



MORE and more firms are saving time and money on finishing work by installing the latest Wadkin Linishing Machines. They are being used on a variety of materials, and applications include components such as automobile window frames, metal windows, bumper bars, metal pattern work, fettling of castings, shop and bar fittings, and metal door furniture. The Wadkin specialists will be pleased to advise as to the most suitable type of abrasive or linishing equipment for your particular material.

WADKIN LTD., GREEN LANE WORKS, LEICESTER. Tel: 68151
LONDON OFFICE: 62 BROOK STREET, W.1. Tel: MAYfair 7048

DRILL and TAP with *EaSiCut*

Whether you are machining parts of this size, or the smallest, leave no room for error. Specify Easicut, the tools you can depend on for a consistent performance.

Drilling and Tapping a cast steel Main Crosshead, weight approximately 114 tons, using Easicut drills 2 1/16″ dia. and Easicut taps 2¼″ B.S.F.

ENGLISH STEEL

TOOL CORPORATION LTD

North Street Works, Openshaw, Manchester

Stocks also held at : 167 Dukes Road, Acton, London, W.3 ; 62-64 Scotswood Road, Newcastle ; 2181 Coventry Road, Sheldon, Birmingham 26 ; Holme Lane Works, Sheffield

LORCO
Hydraulic Oils

are used with . . .

Woodhead-Monroe
Fluid Cushion
Shock Absorbers

THE LONDON OIL REFINING CO. LTD.
ESTABLISHED 1890

LORCO WORKS
LONDON, S.E.15 MANCHESTER 11

---

the book on work study

WORK STUDY

by R. M. Currie, C.B.E., M.I.Mech.E., etc., President of the Work Study Society in conjunction with the British Institute of Management

Because work study is now practised in so many branches of industry, there has been a demand for a complete and authoritative exposition of the subject. This book meets the demand; the author deals thoroughly with every aspect of work study — techniques, the historical background, purposes and functions, its value to management. It is particularly valuable to students; for it is illustrated with a full quota of charts and diagrams, and the nomenclature used is in accordance with that issued by the British Standards Institution. An up-to-date, valuable and important work.
from all booksellers, 22/6 net

Pitman
Parker Street Kingsway London WC2

FOR ADVERTISEMENT SPACE

in this Journal

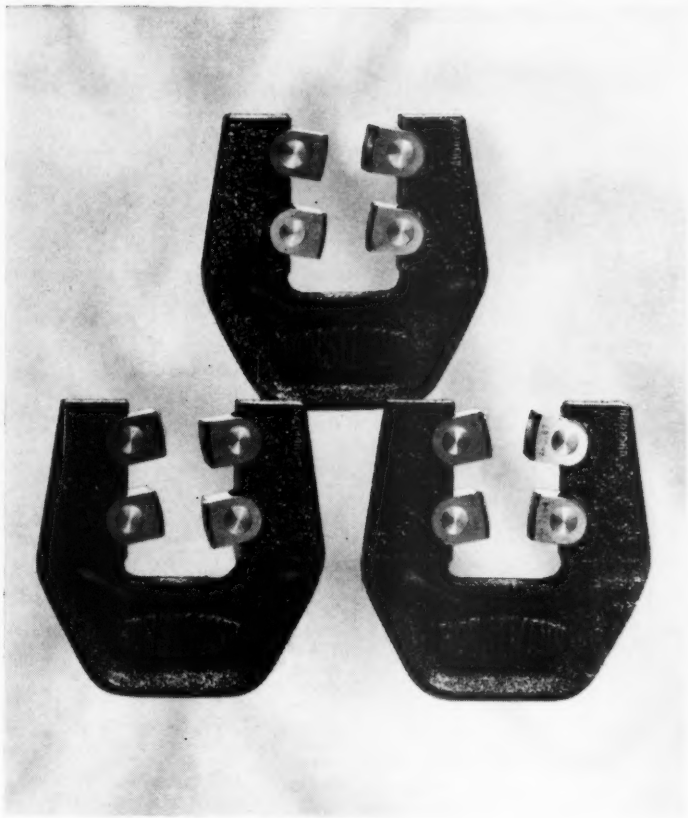
PLEASE CONTACT

T. G. SCOTT & SON LIMITED

1 Clement's Inn,
London, W.C.2.

(Telephone: Holborn 4743)

RATES AND FULL CIRCULATION DETAILS ON REQUEST



Horstmann—A gauge of accuracy

And — for good measure — the Horstmann Model 52 Screw Caliper Gauge incorporates several features which make it versatile, easy to handle and long-lasting.

One of its advantages (as can be seen from the illustration) is that the depth of anvil section makes the Caliper particularly suitable for gauging Acme forms of thread.

Adjustment can be made simply, to meet the different fits and allowances around a nominal thread size and to present alternative thread sectors to the work when wear eventually takes place. The anvil, designed as a section of a large diameter threaded cylinder, prevents shearing of soft work and makes the Horstmann Model 52 ideal for gauging narrow angle threads. The absence of projections from the side of the Caliper frame enables shouldered work to be gauged easily. These anvils do not rotate in use and are suitable for left and right hand threaded workpieces. The Caliper is normally supplied as a "GO" and "NOT GO" combination gauge so that both tests can be applied in one action, but is also available as "GO" only or "NOT GO" only.

It is manufactured in all common thread forms and STOCKED in many standard diameters.

Horstmann also make screw or plain Plug and Ring type gauges All these precision instruments are guaranteed for accuracy, hardness and finish to the requirements laid down by the National Physical Laboratory and British Standards Institution.

We shall be delighted to send you descriptive leaflets.

HORSTMANN

PLUG, RING & CALIPER GAUGES
put accuracy in your hands.

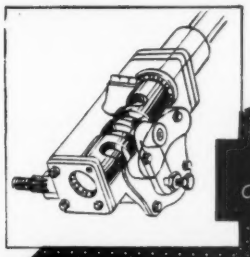
THE HORSTMANN GEAR COMPANY LIMITED
Newbridge Works, Bath, England. Tel: 7241

INDEX TO ADVERTISEMENTS

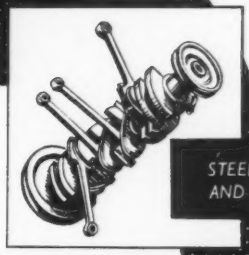
Please note that all advertisement pages are prefixed with the letter "A"

	Page
A.E.I.-Birlec, Ltd.	A7
Adcock & Shipley, Ltd.	A26
Airmec, Ltd.	—
Allen, Edgar, & Co. Ltd.	A34
Archdale, James, & Co. Ltd.	A56
Arrow Electric Switches, Ltd.	—
Asquith, William, Ltd.	A47
Associated Electric Industries, Ltd.	—
Atlas Copco (Great Britain), Ltd.	A65, A103
Automotive Engineering, Ltd.	—
Avery, W. & T., Ltd.	—
B.S.A. Tools, Ltd.	A29
Baker, C., Instruments, Ltd.	—
Barber & Colman, Ltd.	A94
Baty, J. E., & Co. Ltd.	—
Benton & Stone, Ltd.	—
Birmingham Aluminium Casting (1903) Co. Ltd.	A1
Birmingham Tool & Gauge Co. Ltd.	A37
Bishop, Eaves, & Sons, Ltd.	—
Black & Decker, Ltd.	A59
Bliss, E. W. (England), Ltd.	—
Block & Anderson, Ltd.	—
Bolton Railway Wagon & Ironworks Co. Ltd.	A38
Bound Brook Bearings, Ltd.	A80
British Aero Components, Ltd.	A3
British Industrial Eng. Co. (Staffs.), Ltd.	A21
British MonoRail, Ltd.	A28
British Oxygen Gases, Ltd.	—
British Steel Founders' Association	—
British Timken ; Division of The Timken Roller Bearing Co.	A33
Brockhouse, J., & Co. Ltd.	A90
Broom & Wade, Ltd.	A95
Brown, David, Corpn. (Sales), Ltd., The	A24, A25
Buck & Hickman, Ltd.	A19
Bullows, Alfred, & Sons, Ltd. *Inset between*	A16, A17
Burton Griffiths & Co. Ltd.	A29
Butler Machine Tool Co. Ltd., The	—
Calor Gas (Distributing) Co. Ltd.	A93
Canning, W., & Co. Ltd.	A6
Carborundum Co. Ltd., The	—
Catmur Machine Tool Corpn., Ltd.	A30
Churchill, Charles, & Co. Ltd.	—
Churchill Machine Tool Co. Ltd.	A51
Ciba (A.R.L.), Ltd.	A15
Cincinnati Milling Machines, Ltd.	A13
Cohen, Geo., Sons, & Co. Ltd.	—
Concentric Manufacturing Co. Ltd.	—
Cooper & Co. (B'ham), Ltd.	A96
Coventry Climax Engines, Ltd.	—
Crawford Collets, Ltd	A89
Crompton Parkinson, Ltd. (Instruments)	A76
Crompton Parkinson (Stud Welding), Ltd.	A81
Crosland, William, Ltd.	—
Crowthorn Engineering Co. Ltd.	A8
Davis, Stuart, Ltd.	A9
Dawson Bros., Ltd.	A64
Dean Smith & Grace, Ltd.	A16
Denham's Engineering Co. Ltd.	—
Dowding & Doll, Ltd.	A22
Drummond-Asquith, Ltd.	A48
Drummond Bros., Ltd.	A46
E.N.V. Engineering Co. Ltd.	A73, A102
Edwards, F. J., Ltd.	—
Electrical Development Association	A75
Electric Resistance Furnace Co. Ltd.	—
Elliott, B. (Machinery), Ltd.	—
English Electric Co. Ltd., The	—
English Steel Tool Corpn., Ltd.	A105
Exors. of James Mills, Ltd.	—
Firth, Thos., & Brown, John, Ltd.	A62
Flame Hardeners, Ltd.	A98
Fletcher Miller, Ltd.	A9
Flexello Castors & Wheels, Ltd.	A90
Ford Motor Co. Ltd.	A55
Gas Council, The *Outside Back Cover*	
Gear Grinding Co. Ltd.	—
Gledhill-Brook Time Recorders, Ltd.	—
Goulder, J., & Sons, Ltd.	A88
Guest, Keen & Nettlefolds (Midlands), Ltd.	—
Hale & Hale (Tipton), Ltd.	—
Harris, John, Tools, Ltd.	A11
Harrison, T. S., & Sons, Ltd.	A97
Hayes Engineers (Leeds), Ltd.	A74
Heenan & Froude, Ltd.	—
Herbert, Alfred, Ltd.	—
Hey Engineering Co. Ltd.	A84
Hordern, Mason & Edwards, Ltd.	A17
Horstmann Gear Co. Ltd., The	A107
Hüller, Karl, Ltd.	A25
Hurst, M. H. (Engineering), Ltd.	A100
Hymatic Engineering Co. Ltd., The	—
Ilford, Ltd.	A58
Impregnated Diamond Products, Ltd.	A68, A82, A101
Ingersoll-Rand Co. Ltd.	A71
Ingham, Robert, Clark & Co.	—
Integra, Leeds & Northrup, Ltd.	—
International Computers and Tabulators, Ltd.	—
Isopad, Ltd.	—
Jones, E. H. (Machine Tools), Ltd.	A85
Kearns, H. W., & Co. Ltd.	A70
King, Geo. W., Ltd.	A79
Kitchen & Wade, Ltd.	—
Landis Lund, Ltd.	A77
Lang, John, & Sons, Ltd.	A52
Lapointe Machine Tool Co. Ltd.	A51
Lester-Brown Machine Tools, Ltd.	A102
Ley's Malleable Castings Co. Ltd.	—
Lincoln Electric Co. Ltd., The	—
Lloyd, Richard, Ltd.	A32
Lockheed Precision Products, Ltd.	—
Lodge Plugs, Ltd.	A84
London Oil Refining Co. Ltd., The	A106
Macready's Metal Co. Ltd.	A38
Markland Scowcroft, Ltd.	A94
Marsden & Shiers, Ltd.	A104
Martonair, Ltd.	A54
Maxam Power, Ltd.	A57
Measurement, Ltd.	A12
Mechanical Handling	A63
Midgley & Sutcliffe, Ltd.	A98
Midland Pneumatic, Ltd.	A98
Mobil Oil Co. Ltd.	A43
Monks & Crane, Ltd.	A45
Morris, B. O., Ltd.	A87
National Industrial Fuel Efficiency Service	—
Neill, James & Co. (Sheffield), Ltd.	A14
Newall, A. P., & Co. Ltd.	A66
Newall Engineering Co. Ltd.	—
Newall Group Sales, Ltd.	—
Newton, Chambers & Co. Ltd.	—
Norton Grinding Wheel Co. Ltd.	—
Norwood Steel Equipment, Ltd.	A53
Optical Measuring Tools, Ltd.	—
Ormerod Shapers, Ltd.	A91
Osborn, Samuel, & Co. Ltd.	A44
Park Gate Iron & Steel Co. Ltd. *Inside Back Cover*	
Parkinson, J., & Son (Shipley), Ltd.	—
Payne Products International, Ltd.	—
Pearson Panke, Ltd.	—
Pitman, Sir Isaac, & Sons, Ltd.	A106
Pollard Ball & Roller Bearing Co. Ltd.	A49
Powell & Co.	—
Power Jacks, Ltd.	—
Power Petroleum Co. Ltd.	—
Precision Grinding, Ltd.	A4
Protolite, Ltd.	—
Pryor, Edward, & Son, Ltd.	—
Pultra, Ltd.	A60, A61
Pye, Ltd. (Process Heating Division)	A67
Ratcliffe, F. S. (Rochdale), Ltd.	A100
Reavell & Co. Ltd.	A88
Rhodes, Joseph, & Sons, Ltd.	A96
Rockwell Machine Tool Co. Ltd.	A27, A104
Rowland, F. E., & Co. Ltd.	—
Rubery Owen Co. Ltd.	A18
Russell, S., & Sons, Ltd.	A86
Ryder, Thos., & Son, Ltd.	A35
Salter, G., & Co. Ltd.	—
Schrader's, A., & Son	A10
Selson Machine Tool Co. Ltd.	—
Sheffield Twist Drill & Steel Co. Ltd.	A5
Shell-Mex & B.P., Ltd.	—
Smart & Brown (Machine Tools), Ltd.	A60, A61
Smith, John (Keighley), Ltd.	—
Snow & Co. Ltd.	A36
Speed Tools, Ltd.	A86
Standard-Triumph Sales, Ltd.	—
Stein Atkinson Vickers Hydraulics, Ltd.	A83
Sunbeam Anti-Corrosives, Ltd.	—
Super Oil Seals & Gaskets, Ltd.	—
Swift, Geo., & Sons, Ltd.	—
Sykes Machine Tool Co. Ltd., The	—
Sykes, W. E., Ltd.	A42
Talbot Tool Co. Ltd., The	—
Teddington Industrial Equipment, Ltd.	—
Telehoist, Ltd.	A31
Terry, Herbert, & Sons, Ltd.	A72
Tilghman's, Ltd.	A99
Town, Frederick, & Sons, Ltd.	—
United Dominions Trust (Commercial), Ltd.	A20
Universal Tools, Ltd.	A92
Vacu-Blast, Ltd.	A102
Van Moppes, L. M., & Sons (Diamond Tools), Ltd.	—
Varatio-Strateline Gears, Ltd.	A84
Vaughan Associates, Ltd.	—
Vaughan, Edgar, & Co. Ltd	A100
Vickers-Armstrongs (Engineers), Ltd.	A39
Wadkin, Ltd.	A104
Wakefield-Dick Industrial Oils, Ltd.	A41
Ward, H. W., & Co. Ltd.	A50
Ward, Thos. W., Ltd	—
Wayne-Kerr Laboratories, Ltd.	—
Weatherley Oilgear Ltd.	—
Webster & Bennett, Ltd.	A2
West, Allen, & Co. Ltd.	—
Wickman, Ltd.	A40
Wiggin, Henry, & Co. Ltd.	A23
Wild-Barfield Electrical Furnaces, Ltd.	A69
Wilkins & Mitchell, Ltd.	—
Wolverhampton Die Casting Co. Ltd.	—
Woodhouse & Mitchell	A78
Woodside Die Sinking Co. Ltd.	—
Wright Electric Motors (Halifax), Ltd.	—

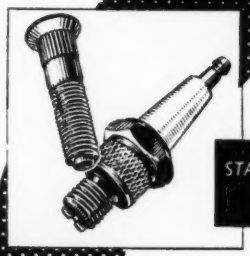
All communications regarding advertisements should be addressed to the Advertising Managers, T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2. Telephone: HOLborn 4743.
Printed by Maxwell, Love & Co. Ltd., 309 - 317 Borough High Street, London, S.E.1.



MILD, CARBON AND CASE-HARDENING STEELS

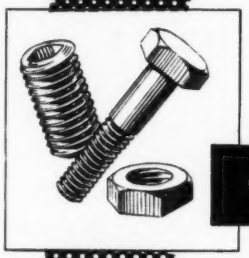


STEELS FOR FORGINGS AND DROP STAMPINGS



STANDARD & HIGH TENSILE FREE CUTTING STEELS

PARK GATE STEELS



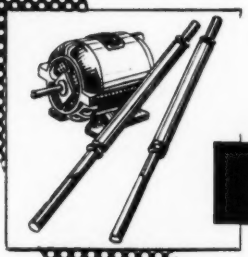
COLD HEADING WIRE

RANGE OF QUALITIES

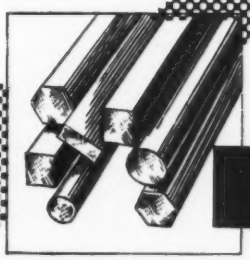
Steels in the carbon range 0·08—0·85%
Case – Hardening Steels
Free Cutting Steels
Low Alloy Steels

RANGE OF PRODUCTS

Billets from 3″ square upwards
Rounds $\frac{3}{8}$″ to 9$\frac{1}{2}$″ Squares $\frac{3}{8}$″ to 4$\frac{1}{2}$″
Hexagons $\frac{3}{8}$″ to 3$\frac{5}{8}$″ Flats 1$\frac{1}{2}$″ to 12″ wide
Coiled Bars $\frac{3}{8}$″ to 1 $\frac{1}{16}$″
Cold Forging Quality Wires
Colliery Arches, Props and Accessories



HARD SHAFT STEELS



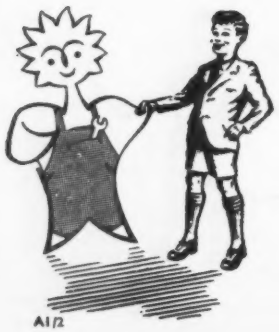
MILD, CARBON AND ALLOY STEEL BARS

THE PARK GATE IRON & STEEL COMPANY LIMITED ROTHERHAM

A Tube Company

TELEPHONE ROTHERHAM 2141 (10 lines) TELEGRAMS YORKSHIRE PARKGATE, YORKS. TELEX 5414

...backed by MR. THERM who Burns to Serve industry always..



...in all ways. Today, computer controlled machine tools—what of tomorrow? He will grow up with Mr. Therm, for each advance in production techniques will be helped by the unceasing research of the Gas Industry into gas utilisation. Through the twelve Area Gas Boards, the Gas Industry offers an unrivalled free technical advisory service on fuel to the many trades and industries which it serves.

Write or 'phone your problem to your Gas Board NOW.

ISSUED BY THE GAS COUNCIL